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RESULTS OF THE PHASE I LONG-TERM ENVIRONMENTAL STORAGE TEST PROGRAM FOR THE RJ43-MA-11 RAMJET ENGINE OCTOBER 1960 THROUGH MARCH 1963

Contract AF 33(657)-7770
Project 273
Model RJ43-MA-11

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RESULTS OF THE PHASE I LONG-TERM ENVIRONMENTAL STORAGE TEST PROGRAM FOR THE RJ43-MA-11 RAMJET ENGINE OCTOBER 1960 THROUGH MARCH 1963

Contract AF 33(657)-7770

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FOREWARD

A long-term storage evaluation program was initiated during CY 1960 under Air Force Contract AF 33(600)-40636 to document the effects of tactical site environment on the storage capability of the RJ43-MA-11 engine as outlined in Marquardt Report S-1001B, Engineering Program Plan for Qualification of the RJ43-MA-11 Ramjet Engine (Reference 1).

For reporting purposes, the long-term storage program was divided into two phases. Phase I storage tests documented the effects of tactical site environment on the engine, combustion chamber, and spare fuel control unit when stored in their respective storage containers. Phase II storage tests will document the effects of tactical site environment on the engine when stored under missile-ready conditions.

This report covers only the Phase I long-term storage test program which was initiated during October 1960 and concluded in March 1963.

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ILLUSTRATIONS (Continued)

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I SUMMARY

A long-term storage evaluation program was initiated during CY 1960 under Air Force Contract AF 33(600)-40636 to document the effects of tactical site environment on the storage capability of the RJ43-MA-11 engine. The phase of testing reported herein covers the documentation of long-term storage effects on the engine, combustion chamber, and spare fuel control unit when stored in their respective shipping/storage containers.

Tests conducted subjected the engine and fuel control unit to (1) vibration and shock loads normally encountered during cross-country shipment, (2) accelerated storage under severe environmental conditions, and (3) long-term (24 months) storage under actual tactical environmental conditions. Effects of the environmental tests on the engine and fuel control unit were evaluated by comparison of pre- and post-storage calibration data and by complete disassembly and inspection of the test items for signs of deterioration.

The storage evaluation showed that with a minimum of maintenance effort, the respective storage containers provide a satisfactory storage environment for engines, combustion chambers, and spare fuel control units under tactical environmental conditions. Confidence in the functional capability of the engine and fuel control unit was demonstrated by the excellent agreement shown between the pre- and post-storage calibration data. Inspection of the disassembled engine and fuel control unit showed practically no signs of deterioration. The storage program conducted indicates that the RJ43-MA-11 engines, combustion chambers, and spare fuel control units stored under tactical environmental conditions in their respective shipping/storage containers, do have a long storage life and confidence can be placed in the operation of the units when put into service subsequent to storage.

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II TEST OBJECTIVE

The prime objective of the long-term storage program is to determine the effect of tactical site environment on the storage capability of the RJ43-MA-11 engine. Specifically, test objectives are to determine: (1) if the life of the engine is compatible with the ten-year design objective; (2) if the two-year interval for conduct of functional confidence checks established in the IM-99B logistics support plan is compatible with the design of the power control system; and (3) what elements, if any, are likely to be troublesome in operational usage of the engine.

III TEST HARDWARE

The test hardware utilized in the Phase I long-term storage test is described below.

A. RJ43-MA-11 Ramjet Engine (P/N X221800, Minus Combustion Chamber Assembly) Serial MA-E10002-2

The engine and its installed fuel control unit (P/N X519000) Serial 002, were formerly test units which were refurbished as required and converted to production item configurations for the storage test. The engine was packaged in a government-furnished, converted Nike shipping container (P/N 59J64205) Type II, in accordance with Marquardt Engineering Drawing 221900, Packaging and Shipping Instructions RJ43-MA-11 Engine (Reference 2).

B. Combustion Chamber Assembly (P/N 221391) Serial 0054

The combustion chamber was new hardware and was packaged in a wooden shipping container (P/N 222120) in accordance with Reference 2.

C. Spare RJ43-MA-11 Fuel Control Unit (P/N X519000-705) Serial 007

The fuel control unit was a former test unit which had been refurbished for the storage program. The -705 modification includes more instrumentation than the basic production item. The fuel control unit was packaged in a shipping container (P/N 222000) in accordance with Marquardt Process Specification 1306D, Preparation of RJ43 Engines for Storage and Shipment, (Reference 3) and the general instructions provided with each container.

IV TEST DISCUSSION

A. Prestorage Operational Test

1. General

Prior to the initiation of the storage tests, each test item was subjected to a comprehensive operational test to determine compliance with the applicable specification governing the operation of the test item. Data from these tests were to provide the criteria for determining satisfactory performance of the test items following the storage test.

2. Test Procedures

The operational test conducted on engine Serial MA-E10002-2 consisted of a complete MIL-Acceptance test, which included a preburn calibration test, a combustion test, and a post-burn calibration test, in accordance with Marquardt Test Specification 0191G, Acceptance Test Specification for the RJ43-MA-11 Ramjet Engine (Reference 4). The test was conducted at the Air Force-Marquardt Jet Laboratory, Ogden, Utah (AF-MJL-O) in October 1960.

The operational test conducted on spare fuel control unit Serial 007 consisted of the equivalent of the MIL-Acceptance preburn calibration test. The test was conducted in accordance with Marquardt Test Specification 0206G, Performance and Calibration Requirements 519000 Fuel Control Unit (Reference 5), at the TMC-Ogden main plant in November 1960.

3. Test Results

Results of the combustion test and calibration tests conducted on engine Serial MA-E10002-2 met all requirements of Reference 4 with one exception. During the post-burn calibration test, the dynamic response of fuel flow to a step in the $P_{t1.4}$ scheduling parameter did not entirely satisfy the Reference 4 requirement (see Table III). The engine was accepted for use in the storage tests without correcting this discrepancy on the basis that the engine would still provide the comparative type data required for a test of this nature. The final or post-burn calibration data are presented in Figures 8 through 10.

Results of the calibration test conducted on fuel control unit Serial 007 met all requirements of Reference 5. Data are presented in Figures 11 through 14.

B. Shipping and Handling Test

1. General

Each test item was to be subjected to the vibration and shock normally encountered by Air Force-accepted items during transport from the factory to the missile base.

2. Test Procedures

Realistic simulation of the vibration and shock loads encountered during handling operations and travel was accomplished by actual cross-country shipment of the engine and spare fuel control unit. At the final destination, the test item shipping containers were inspected for adequate pressurization, desiccant condition, and damage.

3. Test Results

The cross-country route traveled by the test items was a round trip between the TMC facilities at Ogden, Utah, and at Van Nuys, California, a total distance of approximately 1550 miles. Engine Serial MA-E10002-2 was shipped by truck following the prestorage operational test, and the fuel control unit Serial 007 was shipped by rail following the accelerated storage test. At the conclusion of the trips, the shipping containers were found to be in satisfactory condition. Container pressurization was adequate and the humidity indicators showed a safe environmental condition existed inside the containers. The containers were not opened for inspection of the test items.

Each test item traveled an additional 150 miles during the conduct of the remainder of the storage tests, thus the total distance traveled throughout the program was approximately 1700 miles.

C. Accelerated Storage Test

1. General

Accelerated environmental storage techniques were utilized to assist in the evaluation of the design life objective of the test items and to insure satisfactory operation when the test item is stored under severe environmental conditions.

2. Test Procedure

The accelerated storage test was performed as outlined in TMC Report 15039, Environmental Testing of Three Selected RJ43-MA-11 Ramjet Engines and One Fuel Control Unit (Reference 6). A description of

the required test procedure follows.

The test specimens for both the Phase I and Phase II storage tests were placed together in a test chamber, Figure 1, equal to that described in Military Specification MIL-E-5272C (ASG), Environmental Testing, Aeronautical and Associated, General Specification for (Reference 7). The test chamber was vented to the atmosphere to prevent the buildup of pressure. Prior to the start of the test cycle, the chamber temperature was between +68° and +100°F with uncontrolled humidity. Each test cycle consisted of three distinct periods. During the first period of four hours, the temperature was raised to +160°F. This temperature was maintained during the second four-hour period. During the third period which lasted for 16 hours, the temperature in the chamber was gradually reduced to between 68°F and 100°F. The relative humidity was maintained at 95 $\pm$ 5 percent throughout the cycle. Steam or distilled water with a pH value between 6.5 and 7.5 at 77°F was used to obtain the desired humidity. The cycle described was repeated a total of ten times.

At the conclusion of the last cycle described above, the temperature of the test chamber was gradually lowered to -65°F in a three-hour period and maintained at -65°F during the next four-hour period. The temperature was gradually raised to standard conditions during the following three-hour period. The relative humidity was maintained at 15 percent or less during this cycle. The Phase II storage test specimens were removed from the test chamber at the conclusion of this test cycle.

The Phase I test specimens were subjected to the following additional testing. Prior to the start of the test, the chamber temperature was between +68°F and +100°F with uncontrolled humidity. During the first two-hour period, the temperature was gradually lowered to -65°F. The temperature was maintained at -65°F during the next eight-hour period and gradually raised, during the following two-hour period, from -65°F to between +68°F and 100°F. Relative humidity was maintained at 15 percent or less throughout the test cycle. The test cycle described was repeated a total of nine times.

The accelerated storage tests were conducted during November and December 1960 at the facilities of Utah Research and Development Company, Inc., Salt Lake City, Utah. Test chamber temperature was raised by use of a steam generator and lowered by injection of carbon dioxide during the high-temperature, high-humidity cycles. The chamber temperature was lowered by injection of carbon dioxide and raised by dry air from a gas blower during the low-temperature low-humidity cycles. Air circulation within the test chamber was provided by two fans.

3. Test Results

The accelerated storage tests were conducted essentially as outlined in the test procedure, but some deviations were encountered. During one of the high-temperature test cycles, the temperature was erroneously maintained 20°F lower than required. During four of the low-temperature test cycles, the programmed rate of temperature decrease was not sufficient to reach the desired low-temperature level in the time specified. Actual test times and temperatures attained during each test cycle are shown in Tables I and II. Relative humidity was maintained at 100 percent during the high-temperature cycles and at 15 percent or lower during the low temperature cycles. The pH value of the water used for generating steam during the high temperature cycles was 6.8 at 77°F.

Following the tests, the shipping containers were inspected and found to be in satisfactory condition except for some minor corrosion on the unpainted metal fittings on the exterior of the fuel control unit container. The container pressurization was adequate and the humidity indicators showed that a safe environment existed inside the containers. The containers were not opened for inspection of the test items.

D. Long-Term Storage Test

1. General

A 24-month period of storage under natural environmental conditions was conducted to assist in the evaluation of the engine design life, to provide the data necessary to determine if the two-year interval for conduct of functional confidence checks was compatible with the design of the power control system, and to determine what factors, if any, may be troublesome in storage of the engine and fuel control unit.

2. Test Procedures

The engine, combustion chamber assembly, and fuel control unit were stored in their respective storage containers in an outdoor, unprotected locale for a period of two years. The storage area, illustrated by Figure 2, was located at AF-MJL-O from January 1961 to November 1962. In November 1962 the deactivation of AF-MJL-O forced the movement of the test specimens to a new locale at the TMC-Ogden main plant, as illustrated by Figure 3. The test hardware remained at this location until the storage period ended in January 1963.

A record of the weekly high and low temperature in the outdoor storage area was maintained. Weekly inspections of the desiccant condition in the engine and fuel control unit containers and pressure in the engine container were also made. The engine container was repressurized

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as required.

3. Test Results

The storage containers were exposed to widely varying weather conditions during the two-year storage period including ice, snow, rain, dust, salt spray, wind, and sunshine. The outside temperature extremes experienced during the two-year storage period were -12°F and +112°F. Figure 4 presents the weekly high and low temperature readings recorded during the storage period.

It was found that the engine storage container required repressurization at three- to four-month intervals. There was never a need to replace the desiccant in either the engine or fuel control unit storage container as the humidity indicators indicated a safe environment throughout the entire storage test program. The exterior of the shipping containers acquired a weather-beaten appearance as some exterior paint faded and chipped away and some oxidation occurred.

On 15 January 1963 the containers were opened in the presence of the local Air Force Quality Control representative. The fuel control unit storage container, which automatically adjusts the pressure level within the container, was found to be slightly pressurized when opened. A superficial inspection of the test specimens was conducted and all specimens appeared to be in excellent condition. Figures 5 through 7 show the test items at the time the containers were opened.

E. Post-Storage Operational Test

1. General

The effect of the storage tests on the operation of the test items was evaluated by repeating the prestorage operational tests and comparing the test item operation before and after the storage tests.

2. Test Procedure

The post-storage operational test conducted on engine Serial MA-E10002-2 consisted of the postburn calibration test portion of the MIL-Acceptance test and was conducted in accordance with Reference 4. The test was conducted at the TMC-Ogden main plant in February 1963.

The post-storage operational test conducted on spare fuel control unit Serial 007 consisted of a repeat of the prestorage operational test in accordance with Reference 5. The test was conducted at the TMC-Ogden main plant in February 1963.

The tests performed in accordance with References 4 and 5 utilized high pressure fuel in lieu of operating the turbopump. To evaluate the operation of the turbopumps from both fuel control units, a component operational test of each turbopump was performed in accordance with Marquardt Test Specification 0205L, Performance and Calibration Requirements for the Turbopump Assembly (Reference 8), and results were compared to the original component test results.

3. Test Results

The calibration data obtained from the post-storage operational test of engine Serial MA-E10002-2 showed excellent over-all agreement with the prestorage calibration data. There was a slight shift in the data; however, all data remained within calibration tolerances except the $Pt_{1.4}$ dynamic response data which was originally accepted outside the calibration tolerance. A comparison of the pre- and post-storage data for the over-all power control system calibration, Mach senser calibration, shock position control calibration, and turbopump performance are shown in Figures 8 through 10. Dynamic response data are presented in Table III. Functional tests of the signal selector valve system and fuel transfer valve were conducted and performance was satisfactory.

The calibration data obtained from the post-storage operational test of spare fuel control unit Serial 007 showed excellent over-all agreement with the prestorage calibration data except for a lean shift of the minimum power fuel flow schedule at the lower $Pt_{1.4}$ scheduling parameter values. Though the minimum power fuel flow data remained within calibration tolerances, the effect of the minimum power shift caused the maximum power fuel flow datum point at $Pt_{1.4} = 13$ psia to fall 0.017 pps below the lean calibration tolerance. The fuel flow obtained at this point, however, was still well within the operational tolerances. The other systems, although exhibiting some slight shift in data, were all within calibration tolerances. A comparison of the pre- and post-storage data for the over-all power control system calibration, Mach senser calibration, shock position control calibration, dynamic response data, and turbopump performance are shown in Figures 11 through 14. A functional test of the fuel transfer valve showed it to be operating satisfactorily.

F. Test Hardware Disassembly and Inspection

1. General

The object of disassembling and inspecting the test specimens at the conclusions of the storage program was to determine to what extent the test specimens had deteriorated due to effects of the long-term storage.

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2. Test Procedure

Each test specimen was disassembled to the degree that any deterioration of the part could be determined. The degree to which the test specimens were disassembled is shown in Figures 15 through 18. The disassembly was conducted under cognizance of the resident Air Force Quality Control representative. An inspection of each part was made by representatives of the resident Air Force Quality Control office, TMC Quality Control Department, and TMC Engineering Department.

3. Test Results

When disassembled, engine Serial MA-E10002-2 and its associated fuel control unit, Serial 002, were found to be in excellent condition with no signs of deterioration. There was one discrepant area found during disassembly of the fuel control unit but it cannot be attributed to the storage program. Approximately 25 cubic centimeters of water were found in the shock position control assembly. The water was obviously inducted into the control during the post-storage operational test and probably during the functional test of the signal selector valve system. The water, which remained in the control for approximately one week, caused some corrosion on the shock position control valve and bolt and cap assembly, shown in Figure 19. Function of the shock position control was uneffected.

Spare fuel control unit Serial 007 was also found to be in excellent condition. One minor discrepancy was noted on the Mach senser-shock position control housing. This consisted of a small area on the housing, shown in Figure 20, where slight corrosion was evident. This area is open to the atmosphere and, from residue found in the area, had been covered with leak detection soap at the time of initial calibration. It is felt that a flaw in the protective coating in this area combined with the soap, produced the resultant corrosion. This area of the housing has no function other than to provide the area to which the cam adjustment retainer is bolted.

Magnesium elements of this particular engine and fuel control did not have the additional protection afforded by the Marquardt-developed "Marguard" epoxy coating. Production RJ43-MA-11 engine had this processing applied to all magnesium parts with the exception of the external skins.

Inspections of the rubber goods, lubricants, bearing grease, etc., in the engine and fuel control units showed no signs of deterioration.

Combustion chamber assembly Serial 0054 was inspected and found to be in excellent condition.

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TABLE I

SUMMARY OF HIGH TEMPERATURE - HIGH HUMIDITY TEST CYCLE RESULTS DURING THE RJ43-MA-11 ACCELERATED STORAGE TEST

Test Cycles	Period 1		Period 2		Period 3		Relative Humidity (percent)
	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	
TEST REQUIREMENT							
10	4	(68/100 to 160) ± 5	4	160 ± 5	16	(160 to 68/100) ± 5	95 ± 5
TEST RESULTS							
Cycle 1	4	90 to 160	4	160/165	16	160 to 90	100
Cycle 2	4	90 to 160	4	140	16	140 to 73	100
Cycle 3	4	68 to 160	4	160	16	160 to 68	100
Cycle 4	4	80 to 160	4	160	16	160 to 90	100
Cycle 5	4	90 to 150	4	160	16	150 to 90	100
Cycle 6	4	95 to 160	4	150/155	16	162 to 90	100
Cycle 7	4	90 to 160	4	160/165	16	160 to 93	100
Cycle 8	4	90 to 160	4	160/165	16	160 to 90	100
Cycle 9	4	83 to 160	4	160/165	16	160 to 83	100
Cycle 10	4	90 to 160	4	160/165	16	160 to 90	100

NOTE: Temperatures Taken From Temperature Recorder Charts.

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TABLE II

SUMMARY OF LOW TEMPERATURE - LOW HUMIDITY TEST CYCLE RESULTS DURING THE RJ43-MA-11 ACCELERATED STORAGE TEST

TEST REQUIREMENT

Test Cycles	Period 1		Period 2		Period 3		Relative Humidity (percent)
	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	
1	3	(68/100 to -65) ± 5	4	(-65) ± 5	3	(-65 to AMB) ± 5	< 15

TEST RESULTS

Test Cycles	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Relative Humidity (percent)
Cycle 1	3.5	60 to -60	3.75	-60/-65	3	-65 to 60	< 15

TEST REQUIREMENT

Test Cycles	Period 1		Period 2		Period 3		Relative Humidity (percent)
	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Time (hrs.)	Temperature (°F)	
9	2	(68/100 to -65) ± 5	8	(-65) ± 5	2	(-65 to 68/100) ± 5	< 15

TEST RESULTS

Test Cycles	Time (hrs)	Temperature (°F)	Time (hrs)	Temperature (°F)	Time (hrs.)	Temperature (°F)	Relative Humidity (percent)
Cycle 1	2.75	80 to -65	7.5	-65	2	-65 to 70	< 15
Cycle 2	2.5	70 to -62	7.5	-62	1.75	-62 to 80	< 15
Cycle 3	2	70 to -62	8	-62	2	-62 to 75	< 15
Cycle 4	2	75 to -65	8	-60/-68	2	-65 to 75	< 15
Cycle 5	2	75 to -63	8	-63	2	-63 to 80	< 15
Cycle 6	2	80 to -62	7.25	-62	2	-62 to 75	< 15
Cycle 7	2	75 to -62	8	-60/-65	2	-60 to 80	< 15
Cycle 8	2	80 to -63	8	-63/-65	2	-65 to 80	< 15
Cycle 9	2	80 to -65	8	-60/-65	2	-65 to 70	< 15

NOTE: Temperatures Taken From Temperature Recorder Charts.

TABLE III

RJ43-MA-11 RAMJET ENGINE SERIAL MA-E10002-2 DYNAMIC RESPONSE DATA SHEET

Item			Required Dynamic Response Test Check Points	Pre-Storage	Post Storage	Allowed
$P_{26.5}$ DYNAMIC RESPONSE TEST	$P_{26.5}$ STEP INPUT	A	Overshoot	2%	0%	≤ 12%
		B	Rise Time — Time to 50% before overshoot	0.05 Sec.	0.01 Sec.	≤ 0.15 sec.
		C	Final Value Time — time required to reach and remain within ± 10% of final value	0.13 Sec.	0.03 Sec.	≤ 0.50 sec.
	W_{f_t} RESPONSE	A	Dead Time	0.05 Sec.	0.07 Sec.	≤ 0.30 sec.
		B	Overshoot	9%	0%	≤ 15%
		C	50% Response Time before overshoot	0.18 Sec.	0.37 Sec.	≤ 0.50 sec.
		D	Final Value Time — time to reach and remain within ± 10% of final value	0.39 Sec.	0.65 Sec.	≤ .85 sec.
$P_{t_{1.4}}$ DYNAMIC RESPONSE TEST	$Pt_{1.4}$ STEP INPUT	A	Rise Time — time to 50% value before overshoot	0.06 Sec.	0.06 Sec.	≤ 0.15 sec.
		B	Final Value Time — time to reach and remain within ± 10% of final value	0.19 Sec.	0.17 Sec.	≤ 0.40 sec.
	W_{f_t} RESPONSE	A	Dead Time	0.05 Sec.	0.06 Sec.	≤ 0.20 sec.
		B	Overshoot	0%	0%	≤ 15%
		C	50% Response Time before overshoot	0.21 Sec.	0.25 Sec.	≤ 0.25 sec.
		D	90% Response Time before overshoot	0.84 Sec.*	0.76 Sec.	≤ 0.40 sec.
		E	Final Value Time — time required to reach and remain within ± 10% of final value	0.84 Sec.*	0.76 Sec.	≤ 0.65 sec.
P_{t_6} DYNAMIC RESPONSE TEST	P_{t_6} STEP INPUT	A	Overshoot	2%	2%	≤ 12%
		B	50% Response Time before overshoot	0.03 Sec.	0.01 Sec.	≤ 0.20 sec.
		C	Final Value Time — time to reach and remain within ± 10% of final value	0.06 Sec.	0.21 Sec.	≤ 0.40 sec.
	W_{f_t} RESPONSE	A	Dead Time	0.12 Sec.	0.21 Sec.	≤ 0.30 sec.
		B	Overshoot	0%	0%	≤ 15%
		C	50% Response Time before overshoot	0.18 Sec.	0.30 Sec.	≤ 0.50 sec.
		D	Final Value Time — time required to reach and remain within ± 10% of final value	0.35 Sec.	0.50 Sec.	≤ 0.85 sec.

NOTE: All times are measured from the zero time point of the step input.

*Accepted to use "as is" by TMC variation #4757 Item 2

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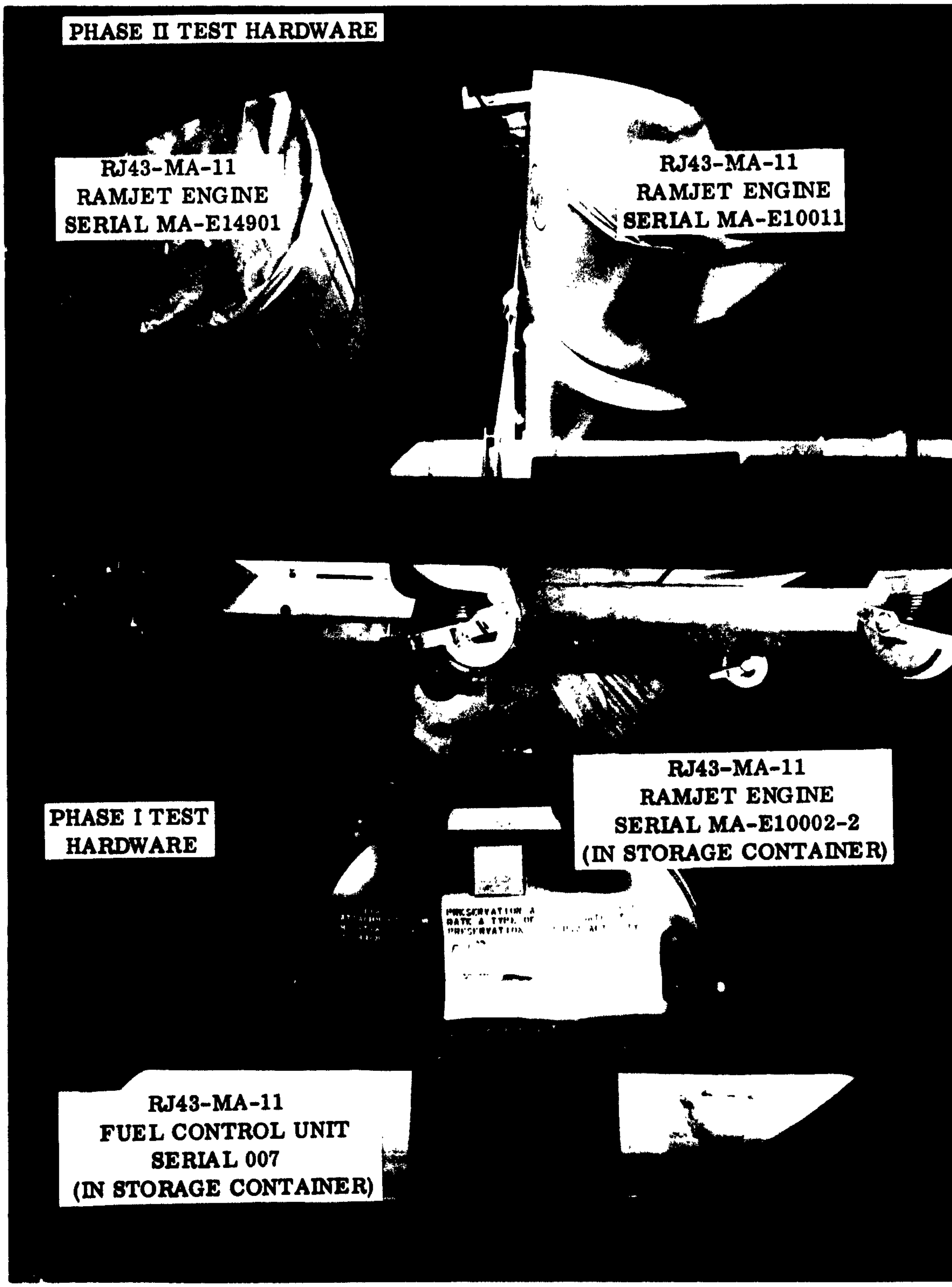

FIGURE 1 - RJ43-MA-11 Test Hardware Installed in an Environmental Test Chamber at the Start of the Accelerated Storage Test Phase of the RJ43-MA-11 Phase I Long Term Storage Test.

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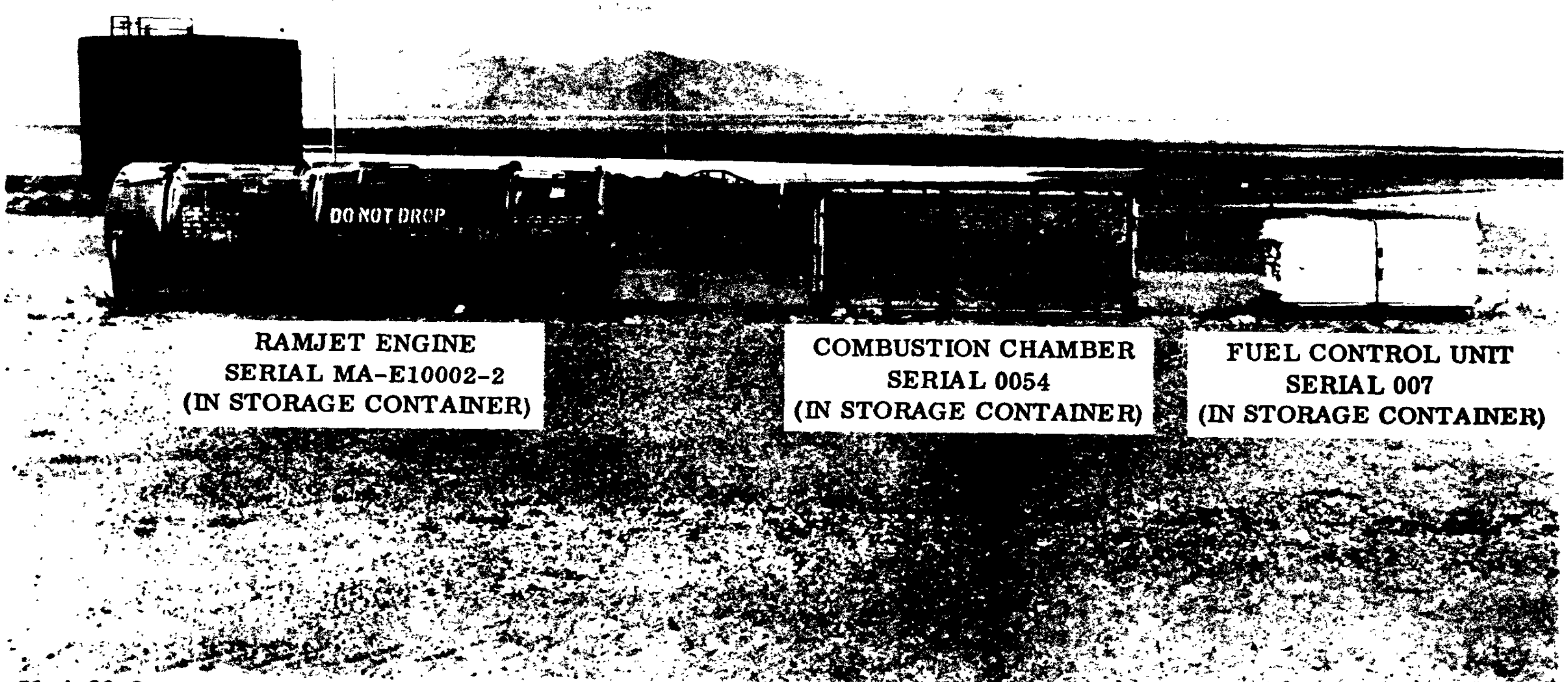

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FIGURE 2 - Storage Area Site, From January 1961 to November 1962, for the RJ43-MA-11 Phase I Long Term Storage Test. Area is Located at the Air Force-Marquardt Jet Laboratory West of Ogden, Utah.

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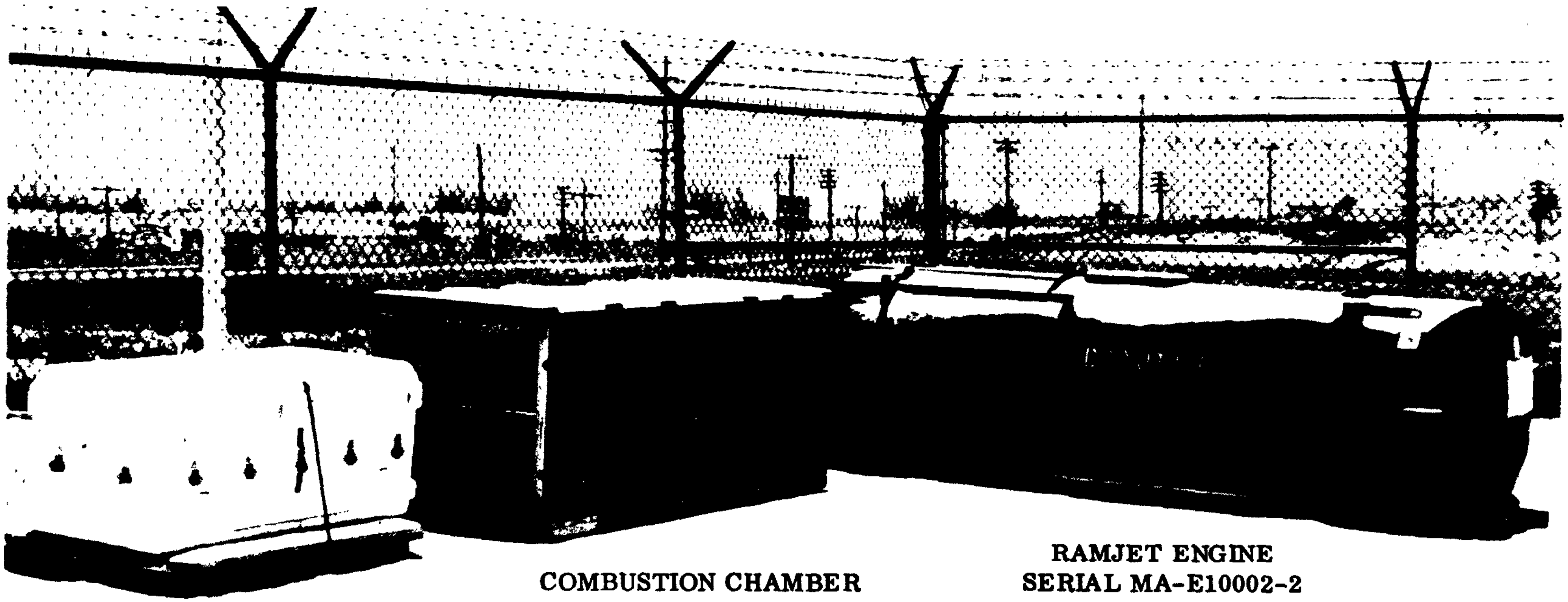

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FIGURE 3 - Storage Area Site, From November 1962 to January 1963, For the RJ43-MA-11 Phase I Long Term Storage Test. Area is Located at The Marquardt Corporation Main Plant in Ogden, Utah.

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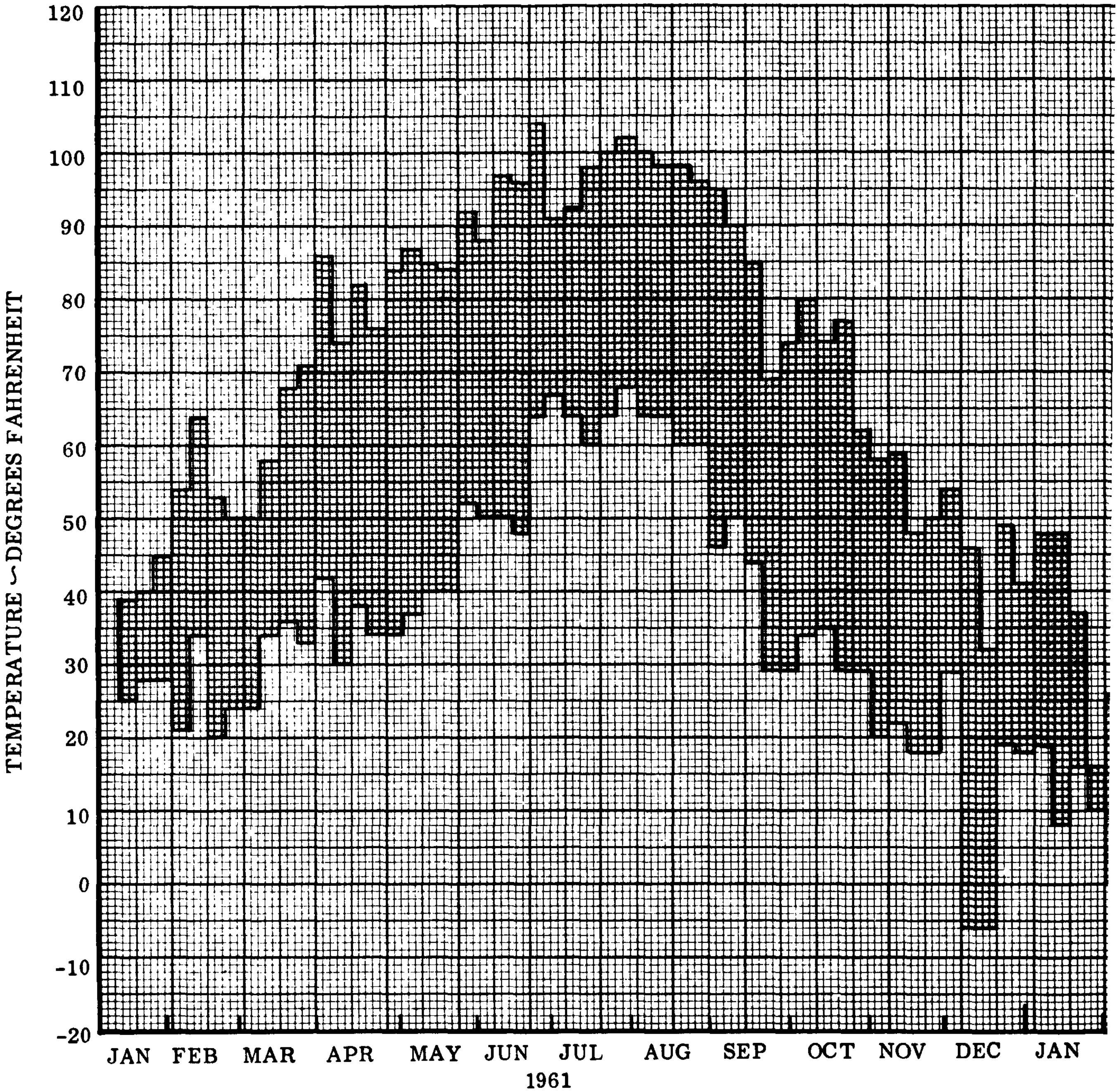
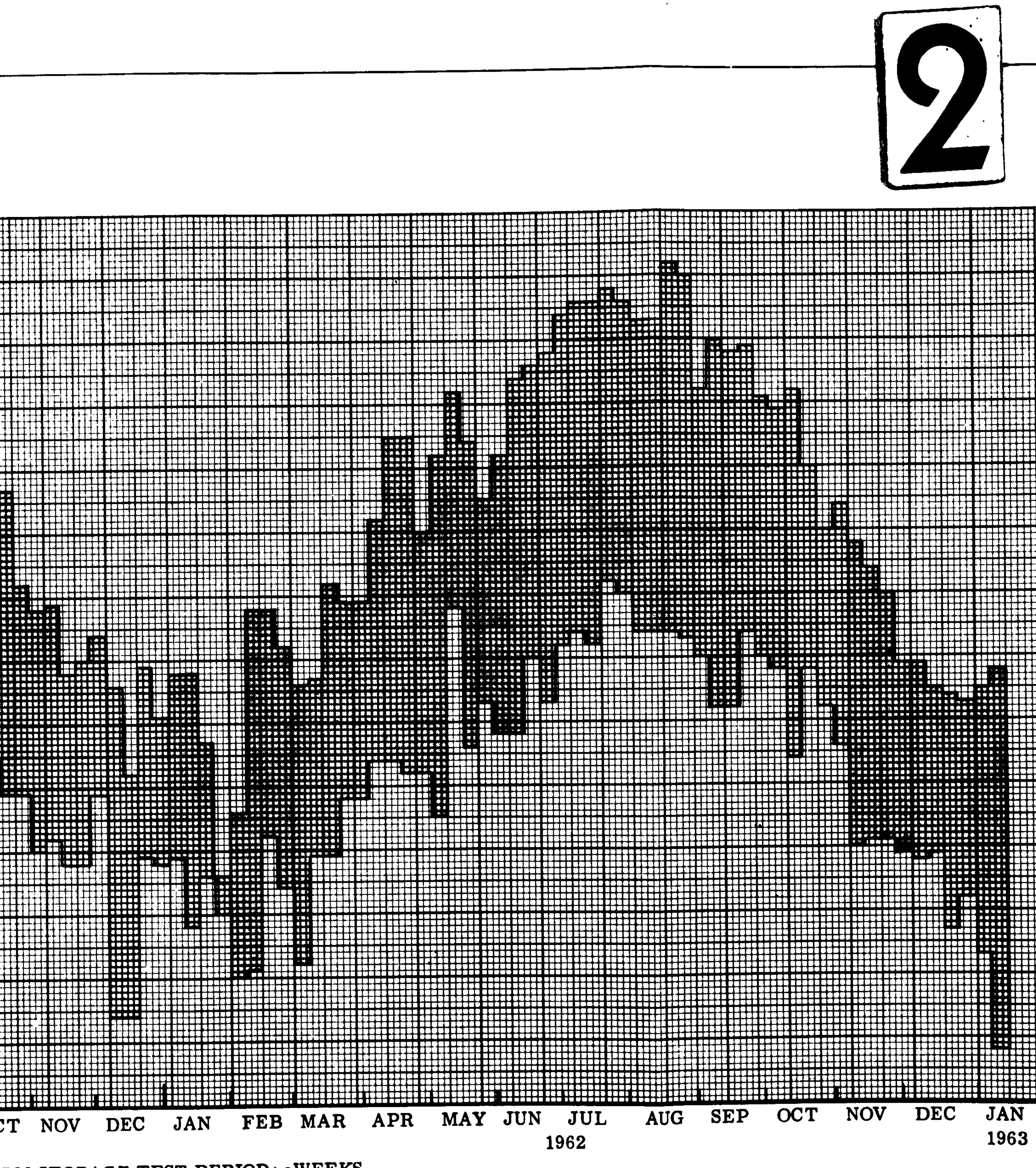
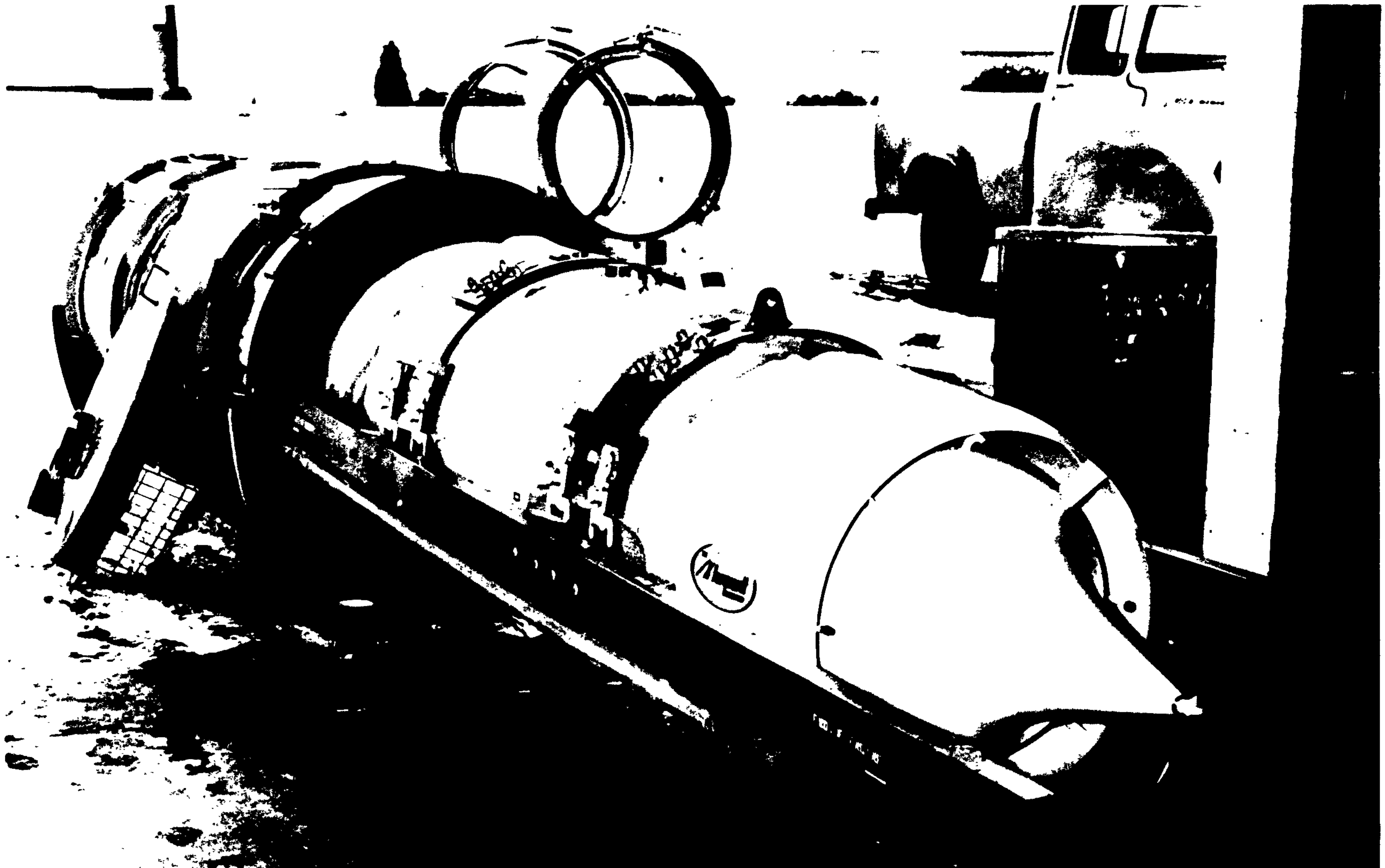


LONG TERM STORAGE TEST PER

FIGURE 4 - Weekly High and Low Temperatures Recorded in the Outdoor S
Long-Term Storage Test.



Recorded in the Outdoor Storage Area During the RJ43-MA-11 Phase I

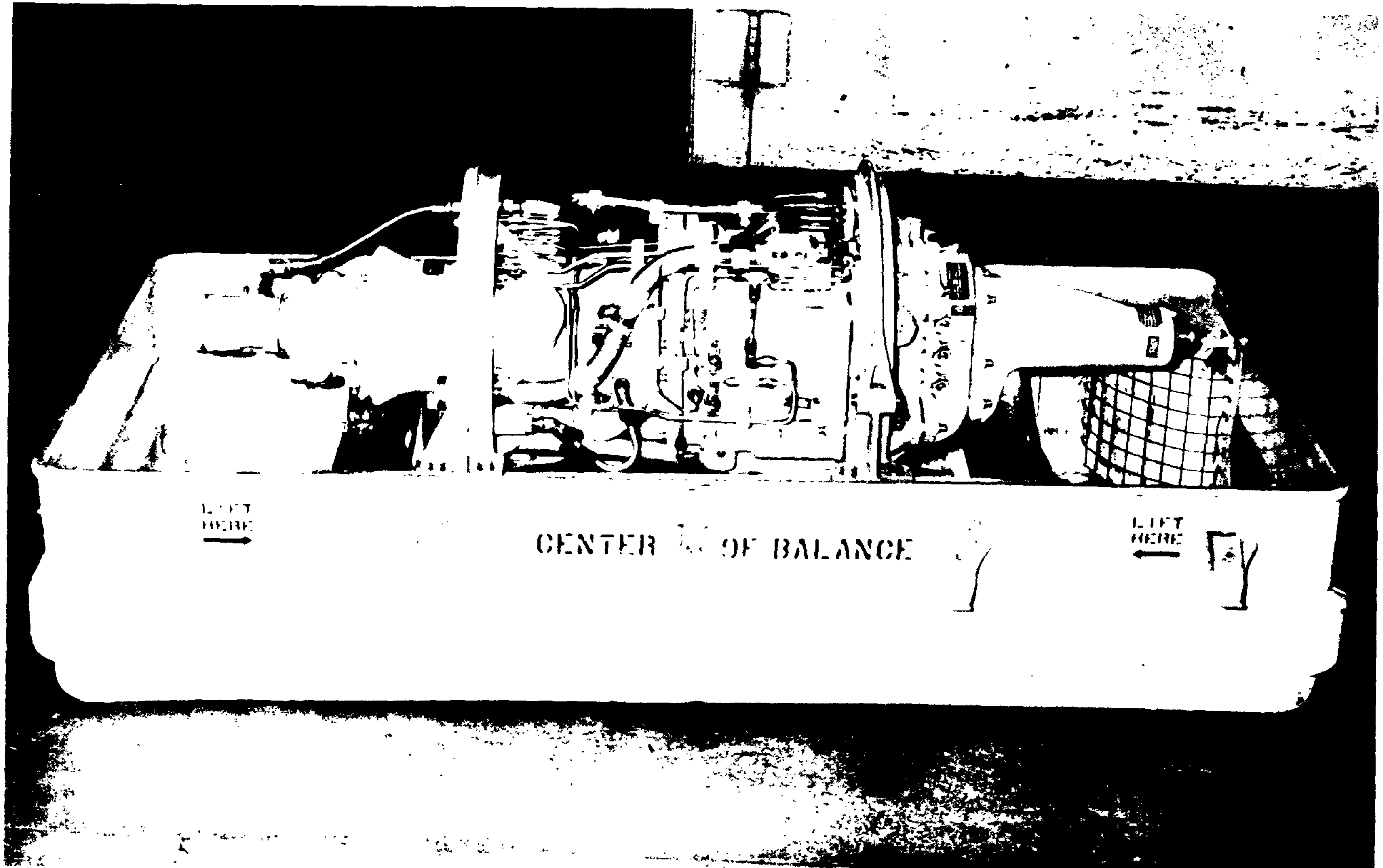


1.14.3-24

FIGURE 5 - RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Being Removed From its Storage Container at the Conclusion of the RJ43-MA-11 Phase I Long Term Storage Test.

1.14.3-23

FIGURE 6 - RJ43-MA-11 Combustion Chamber Assembly Serial 0054 Being Removed From its Storage Container at the Conclusion of the RJ43-MA-11 Phase I Long Term Storage Test.



1.14.3-21

FIGURE 7 - RJ43-MA-11 Fuel Control Unit Serial 007 Being Removed From its Storage Container at the Conclusion of the RJ43-MA-11 Phase I Long Term Storage Test.

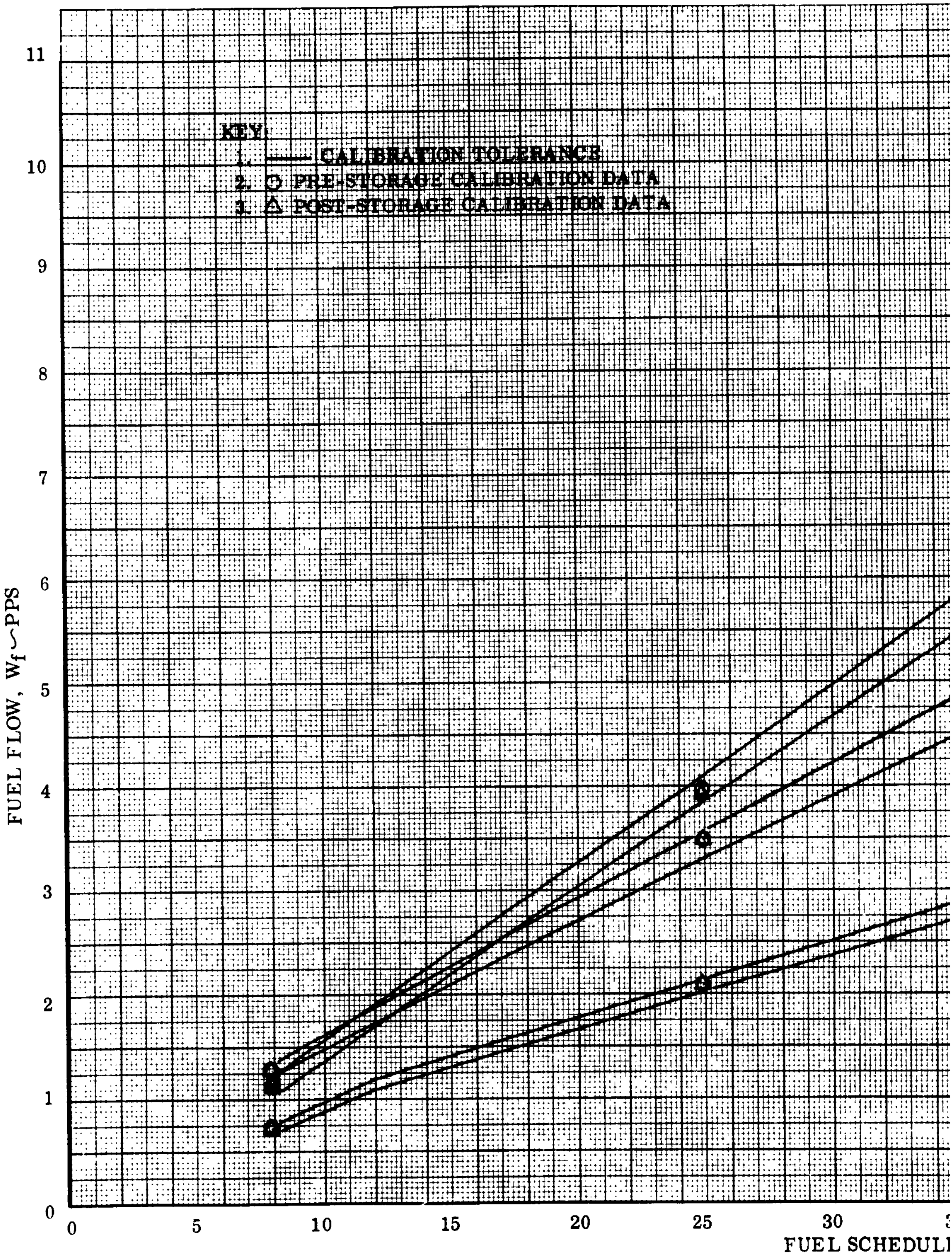
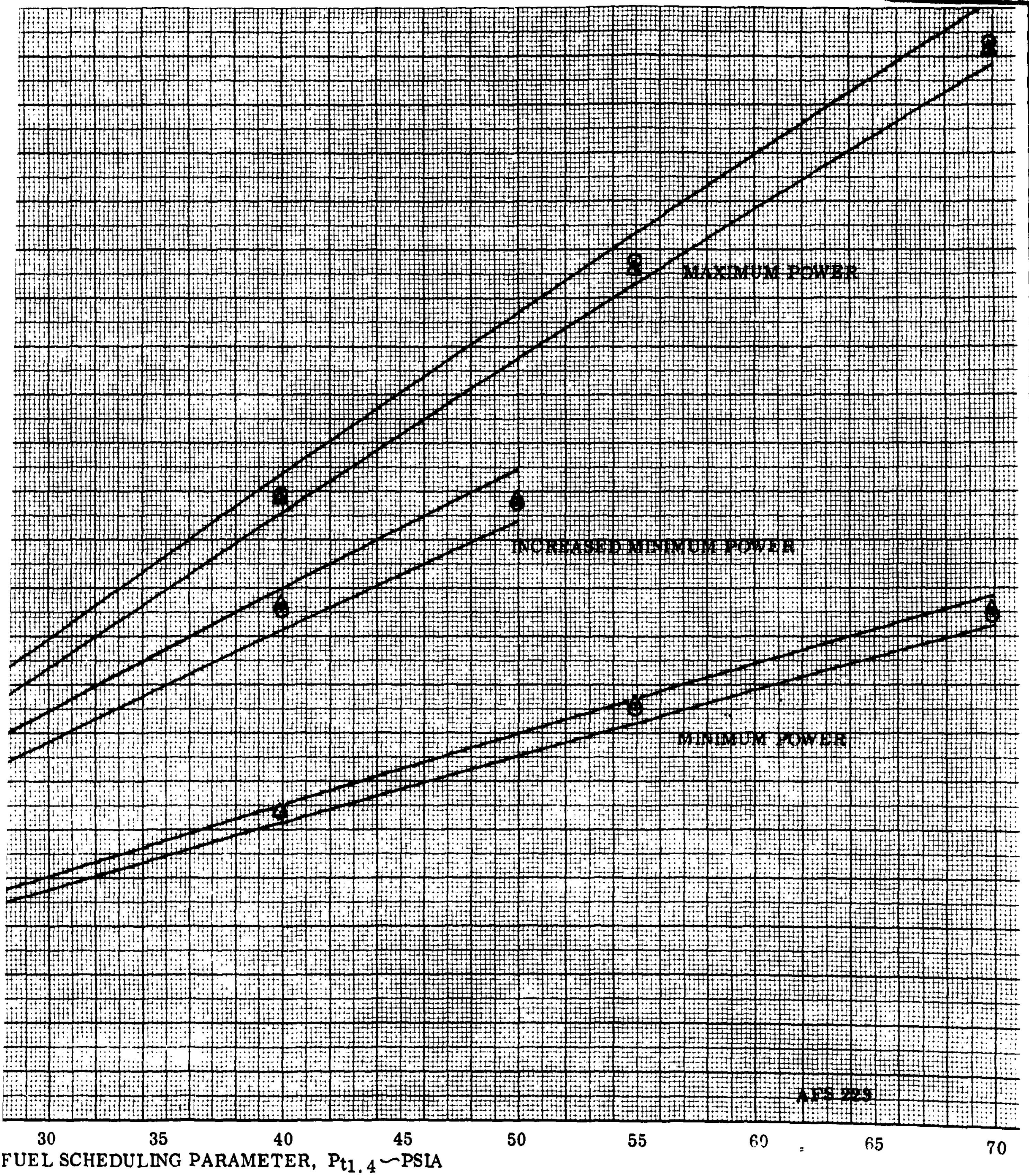
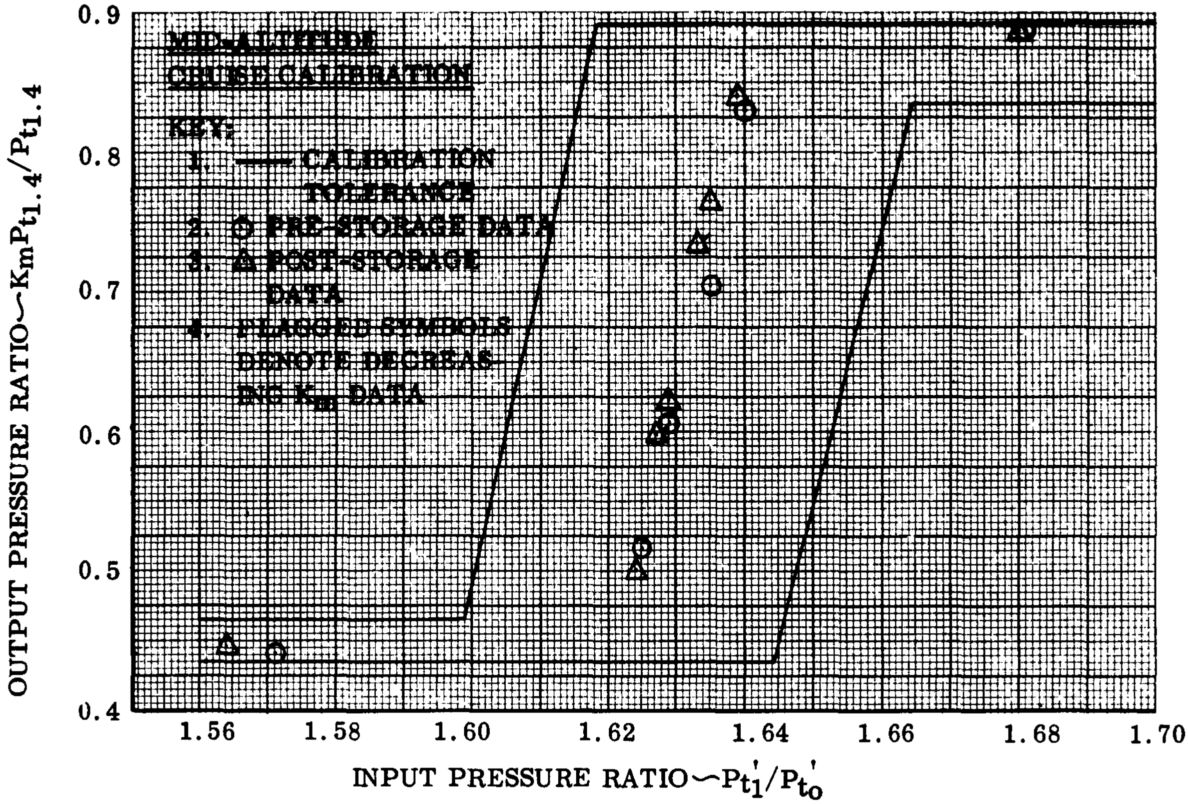


FIGURE 8 - RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Over-all Power Control Sys



'ower Control System Calibration Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.



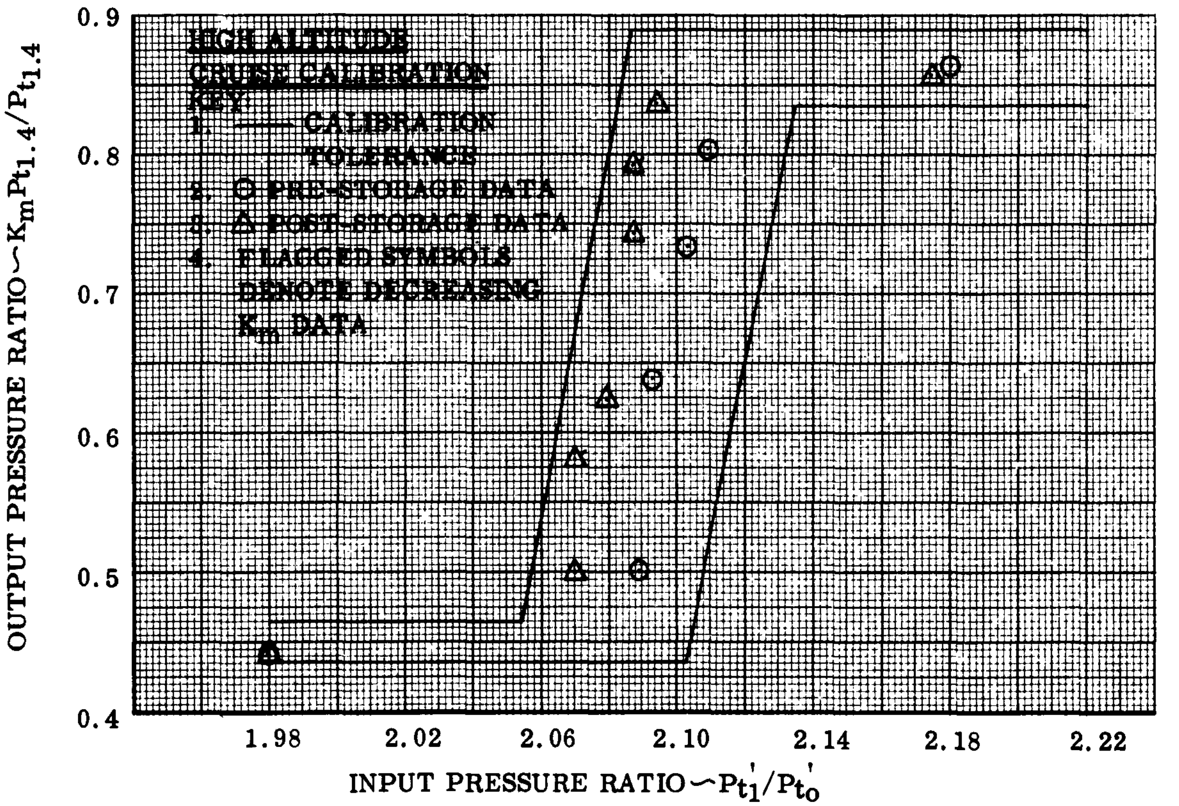


FIGURE 9 - RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Mach Senser Control Calibration Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.

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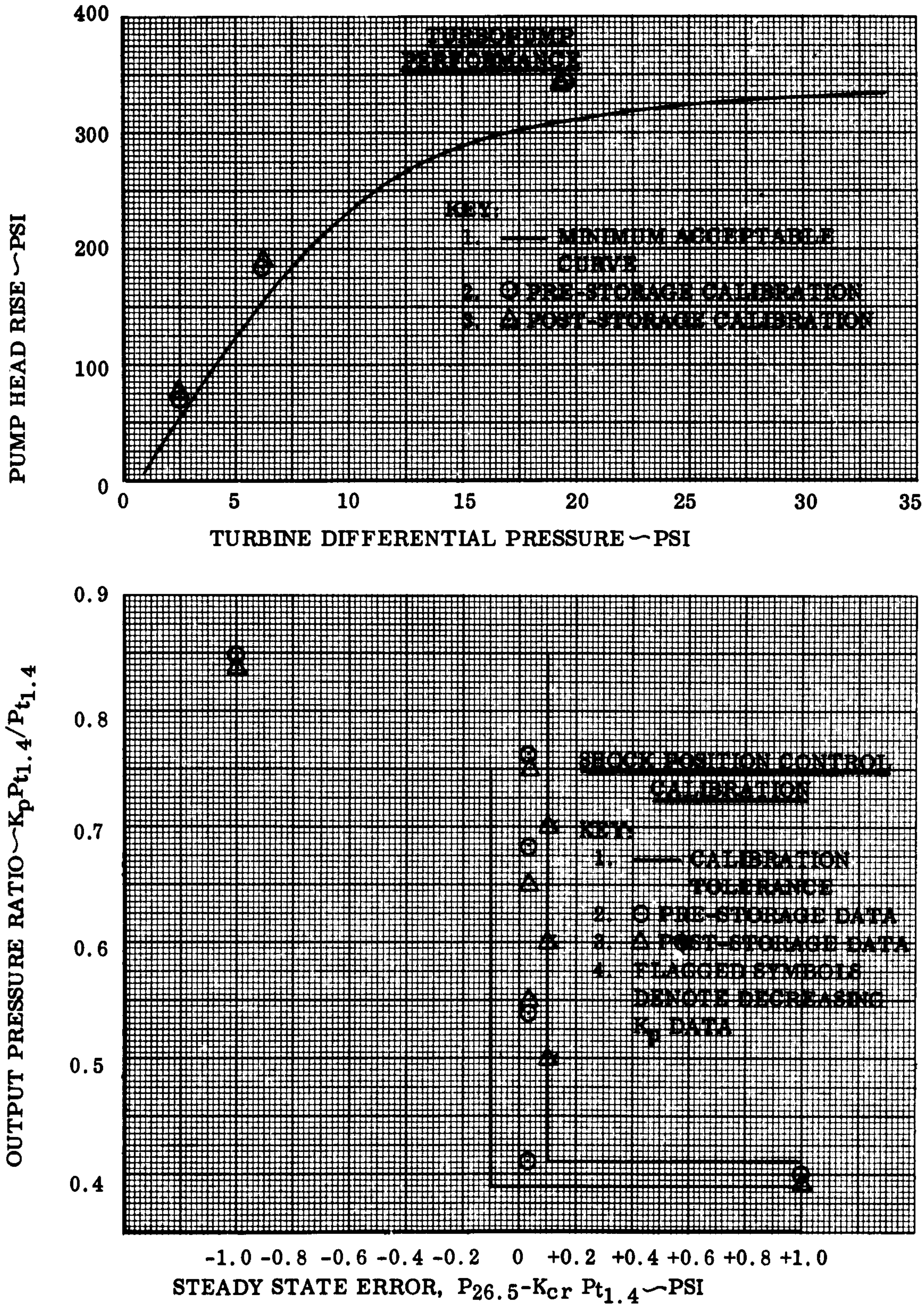


FIGURE 10 - RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Shock Position Control Calibration and Turbopump Performance Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.

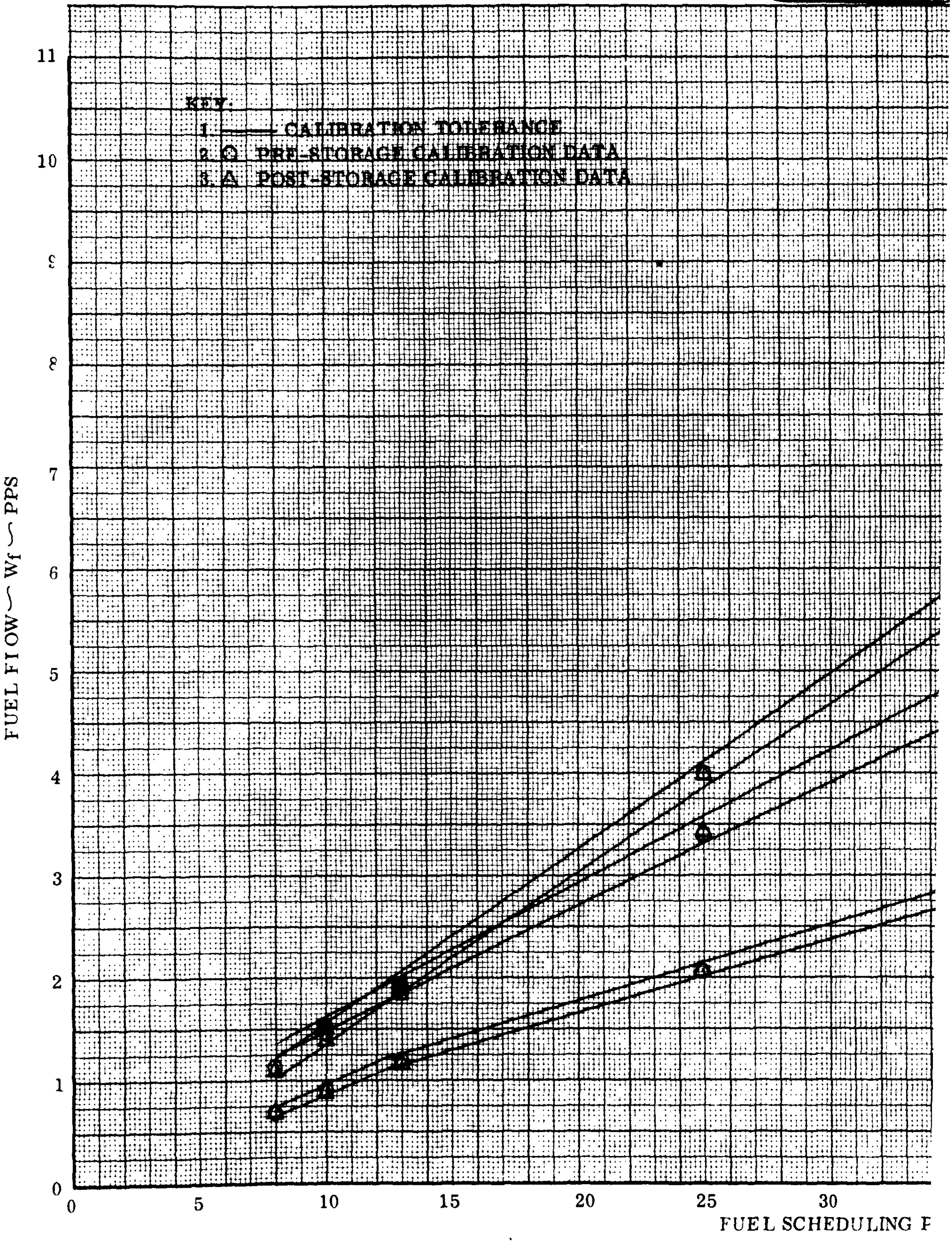
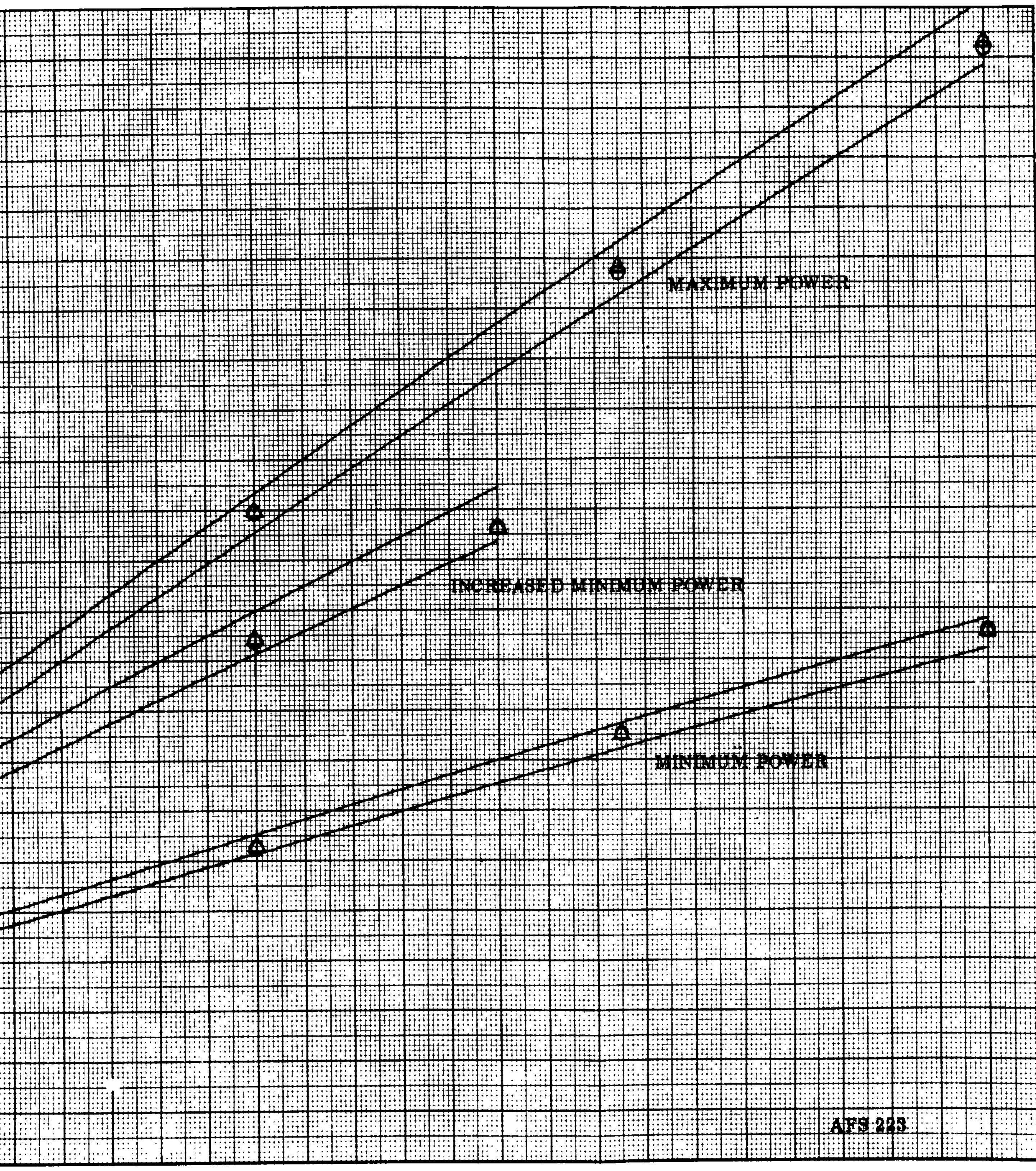


FIGURE 11 - RJ43-MA-11 Fuel Control Unit Serial 007 Over-all Power Control S



ver Control System Calibration Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.

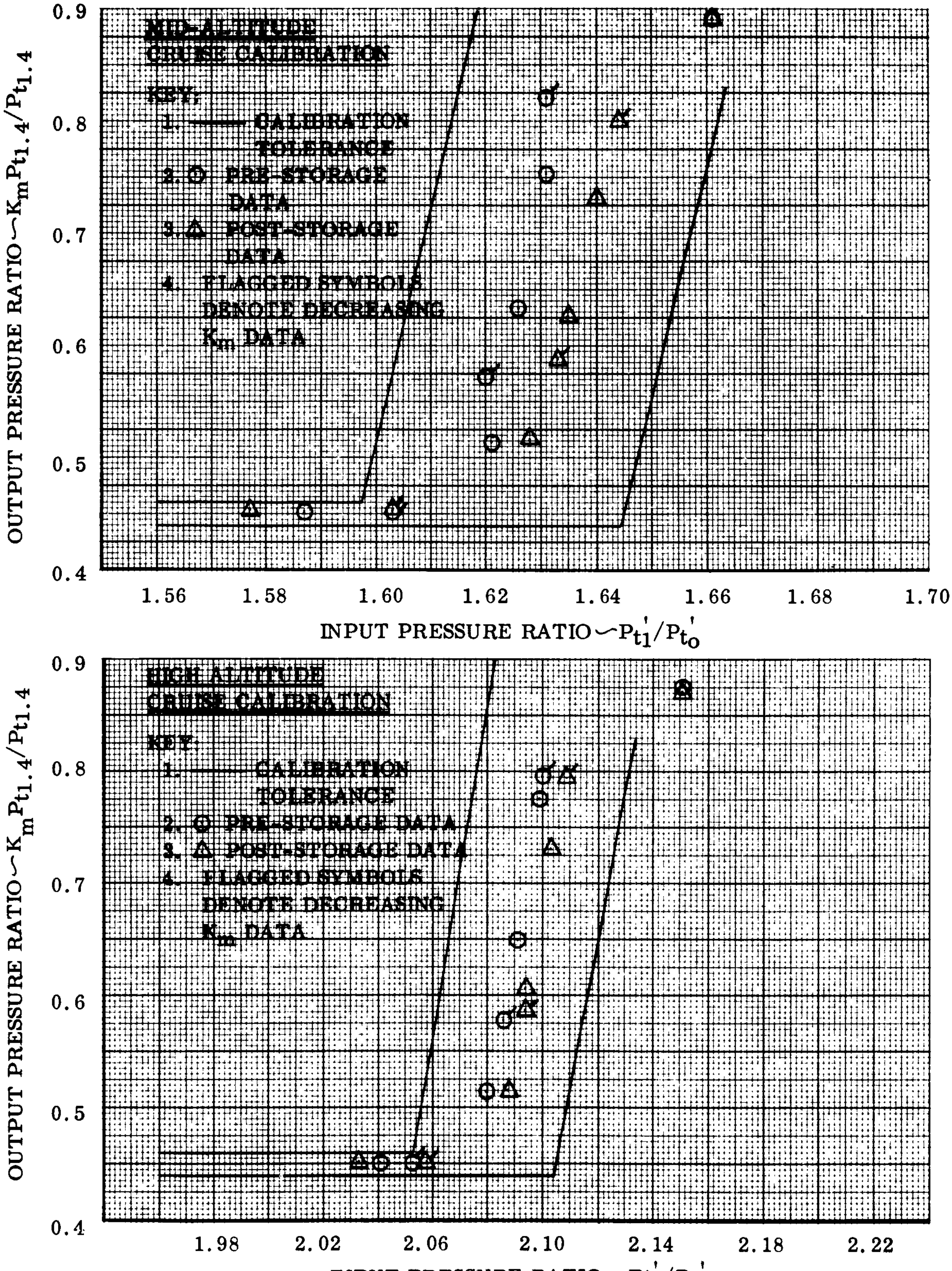
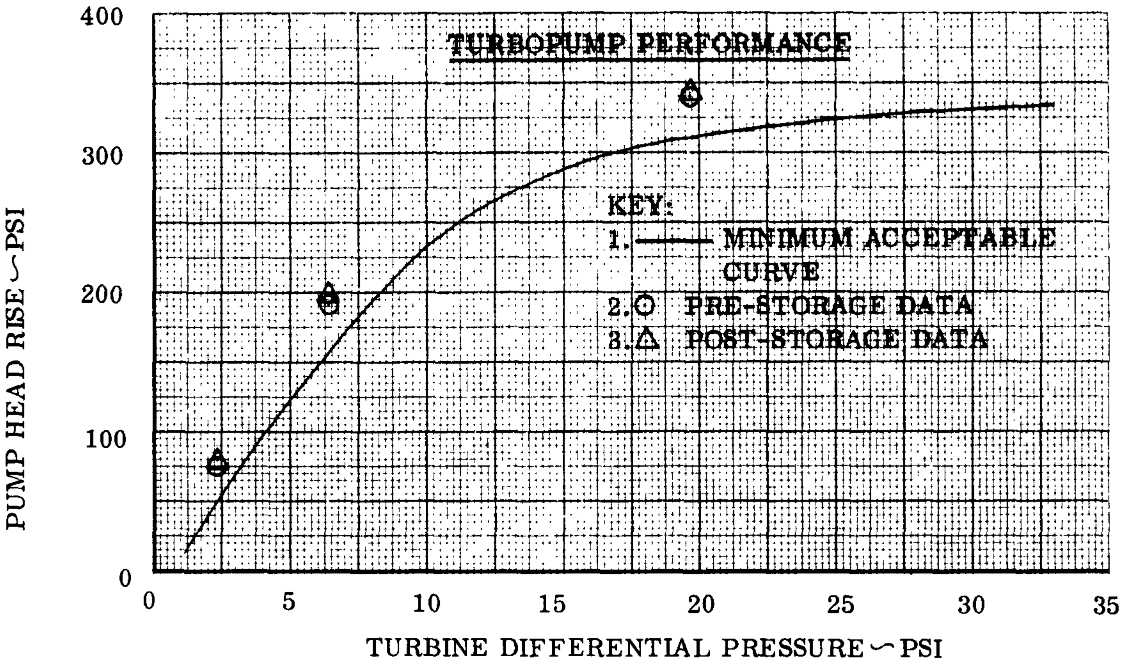


FIGURE 12 - RJ43-MA-11 Fuel Control Unit Serial 007 Mach Senser Control Calibration Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.



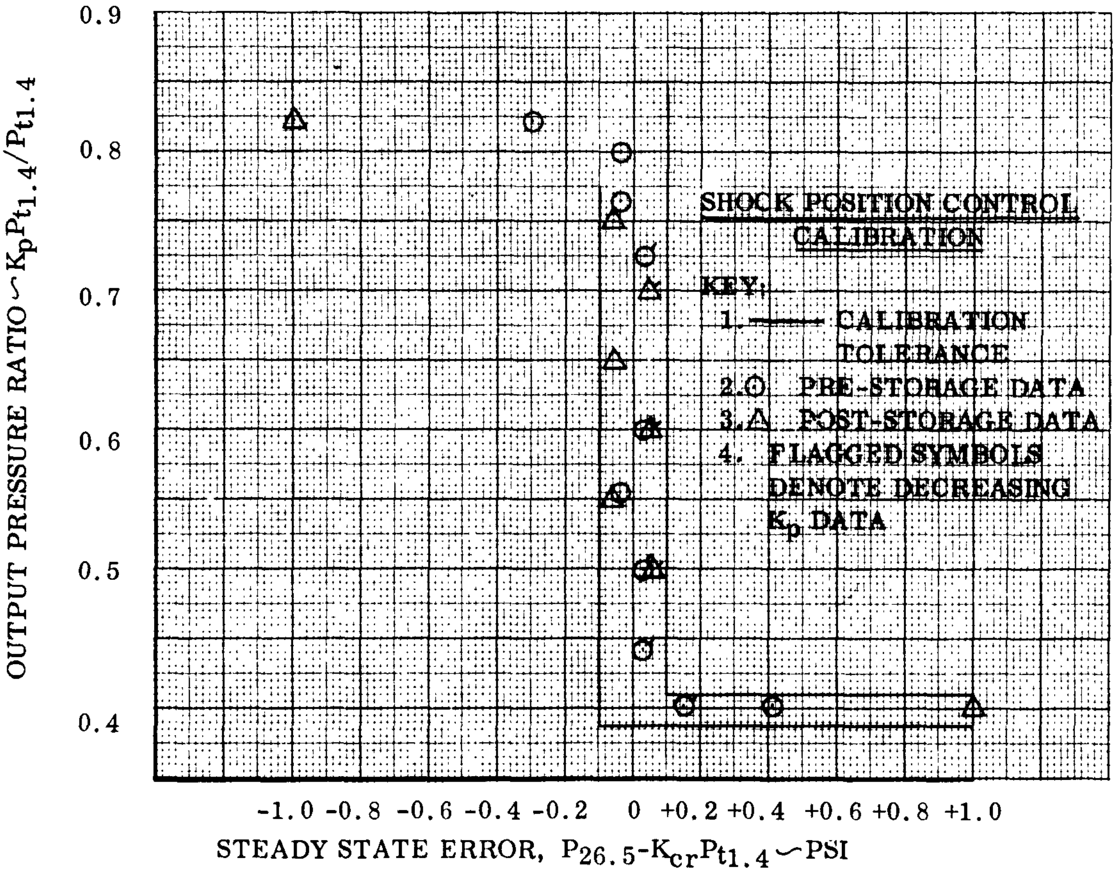


FIGURE 13 - RJ43-MA-11 Fuel Control Unit Serial 007 Shock Position Control Calibration and Turbopump Performance Data Before and After the RJ43-MA-11 Phase I Long-Term Storage Test.

KEY:
1. —— CALIBRATION TOLERANCE
2. ⊙ PRE-STORAGE DATA
3. △ POST-STORAGE DATA

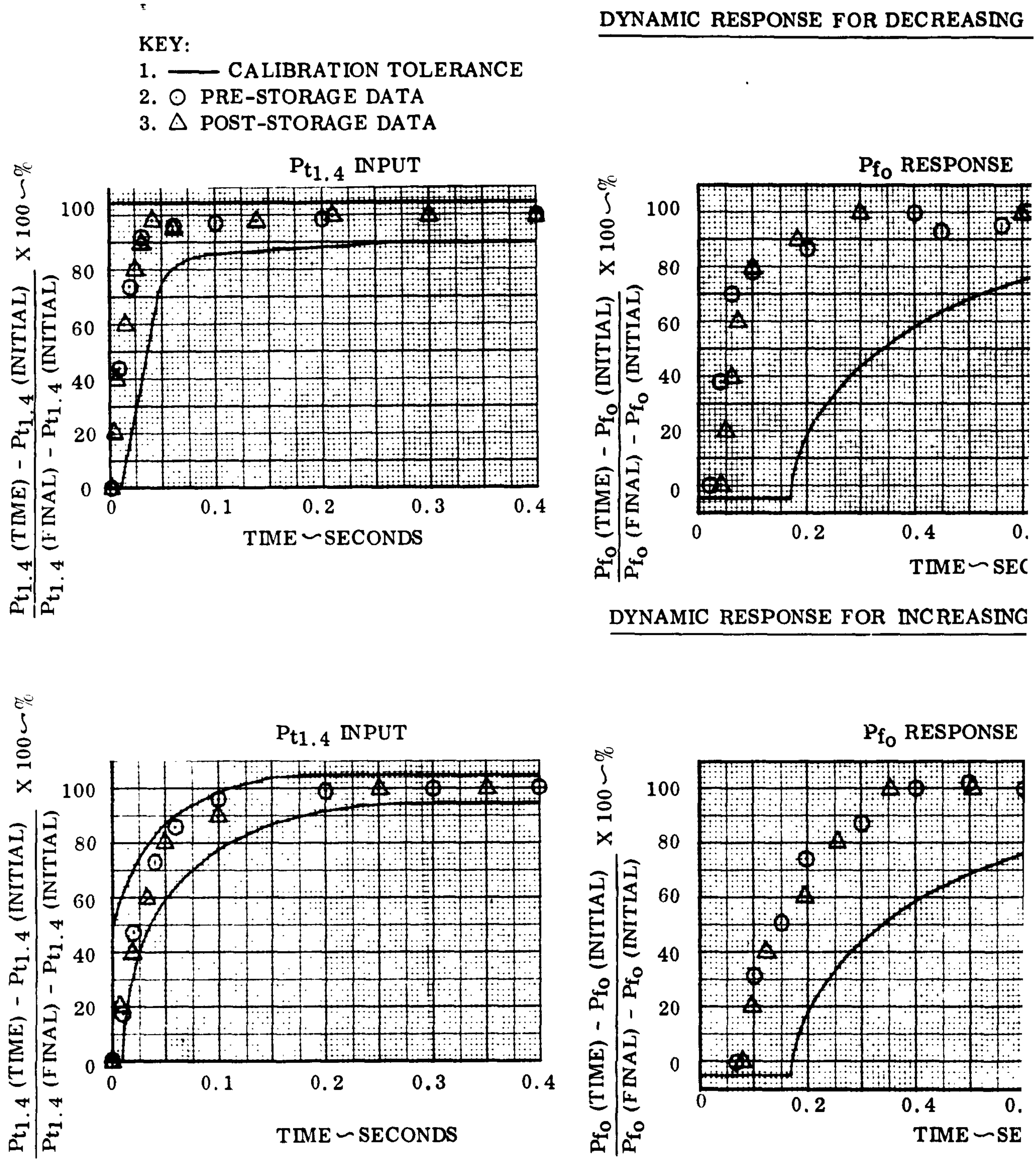
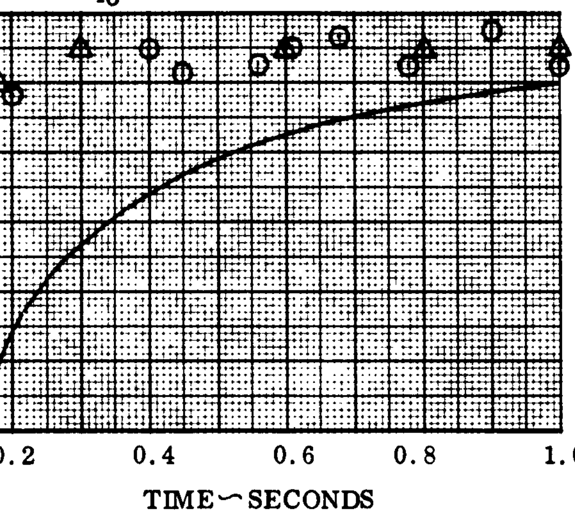


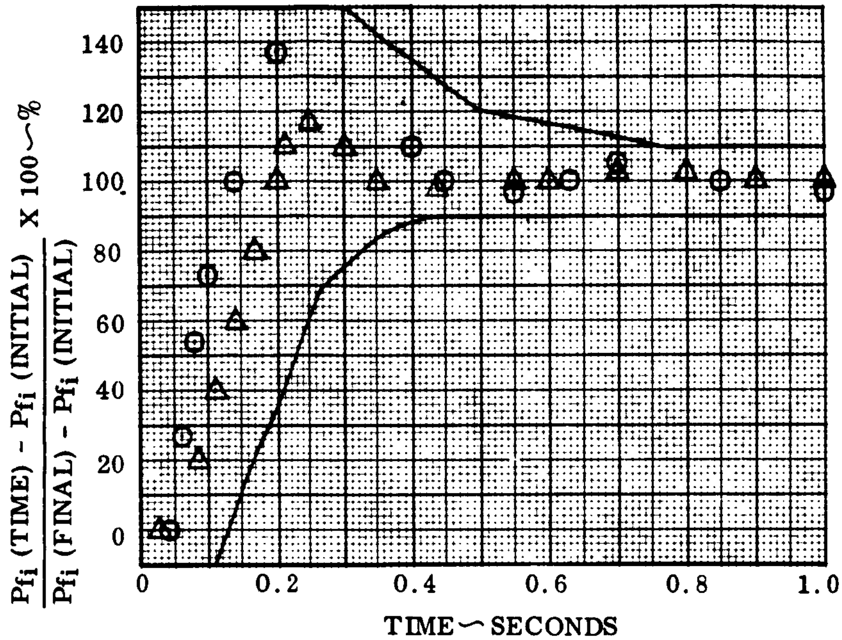
FIGURE 14 - RJ43-MA-11 Fuel Control Unit Se
Data Before and After the RJ43-M
Storage Test.

SE FOR DECREASING DISTURBANCE IN $P_{t_{1.4}}$

P_{f_o} RESPONSE

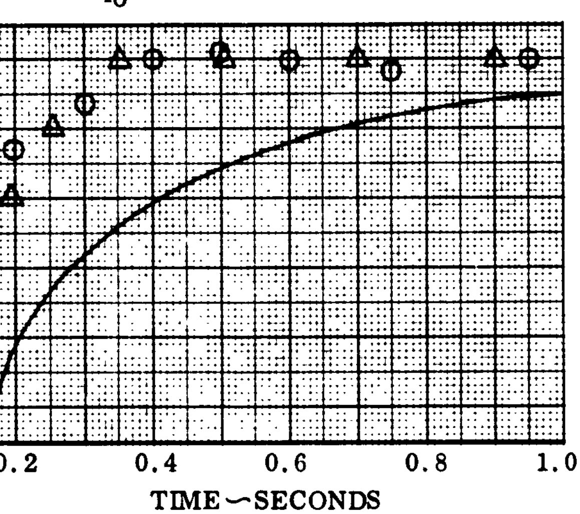


P_{f_i} RESPONSE

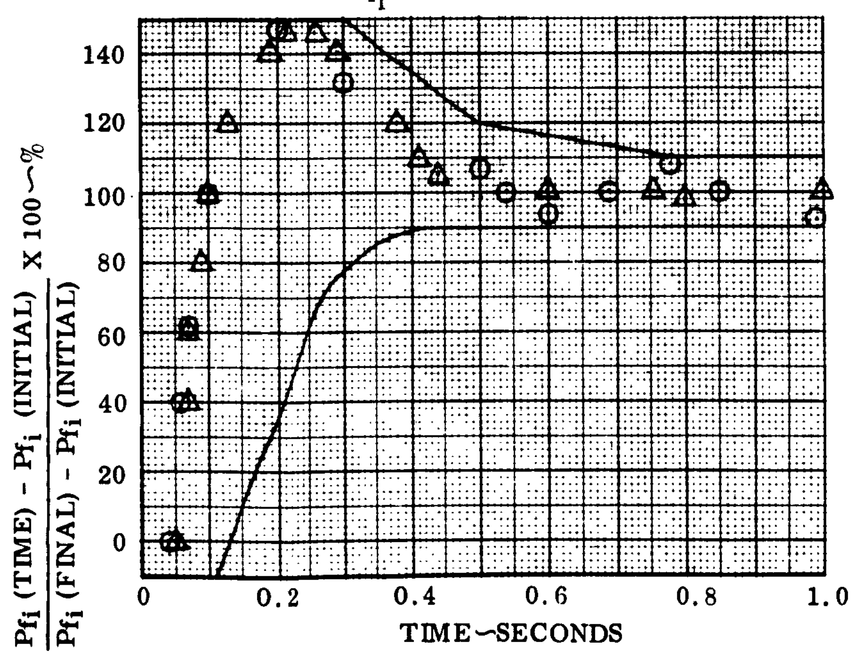


NSE FOR INCREASING DISTRUBANCE IN $P_{t_{1.4}}$

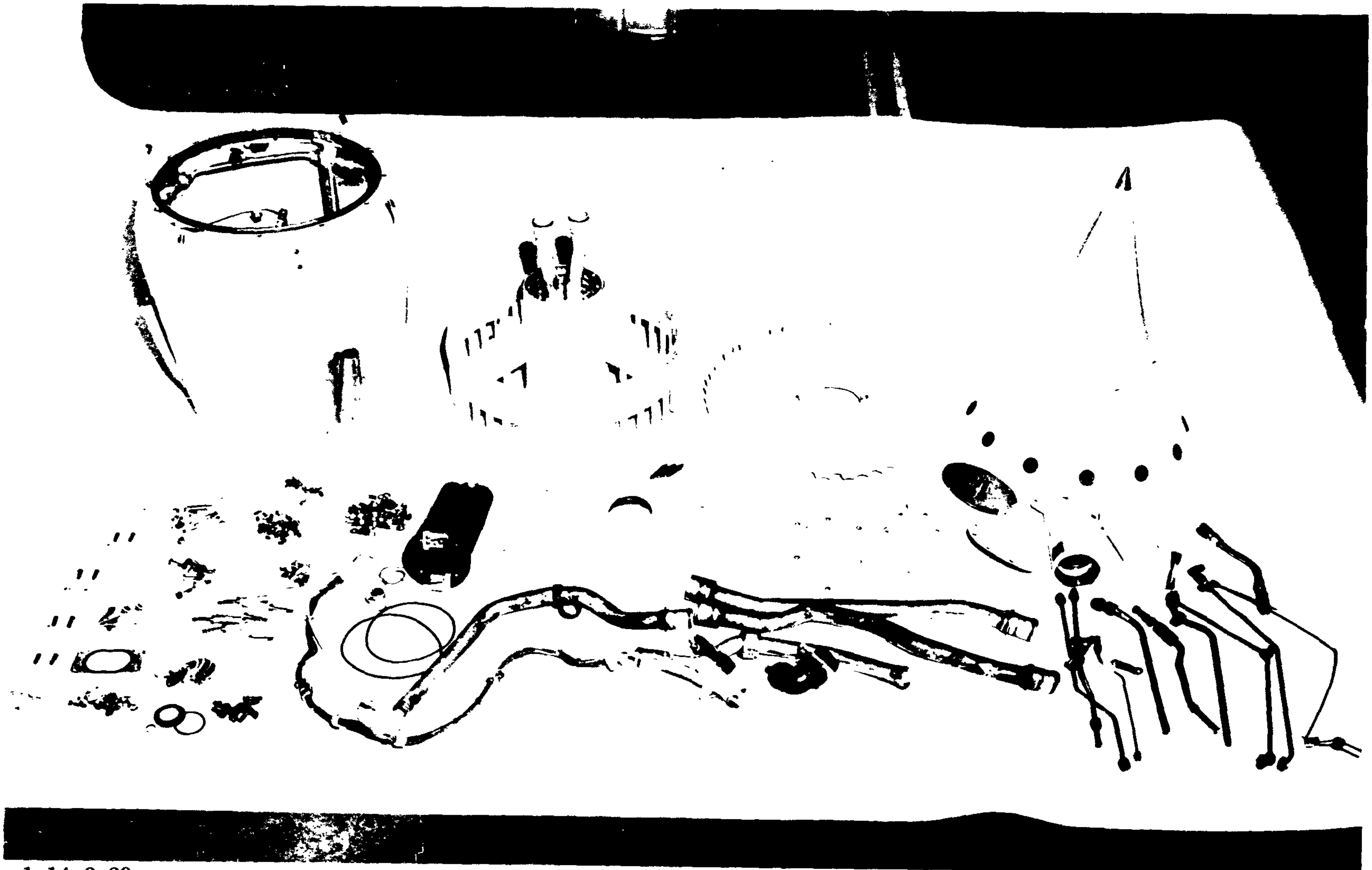
P_{f_o} RESPONSE



P_{f_i} RESPONSE



l Fuel Control Unit Serial 007 Dynamic Response
and After the RJ43-MA-11 Phase I Long-Term
t.



1.14.3-29

FIGURE 15 - Disassembled Components of RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Following the RJ43-MA-11 Phase I Long Term Storage Test.

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1.14.3-30

FIGURE 16 - Disassembled Components of RJ43-MA-11 Ramjet Engine Serial MA-E10002-2 Following the RJ43-MA-11 Phase I Long Term Storage Test.

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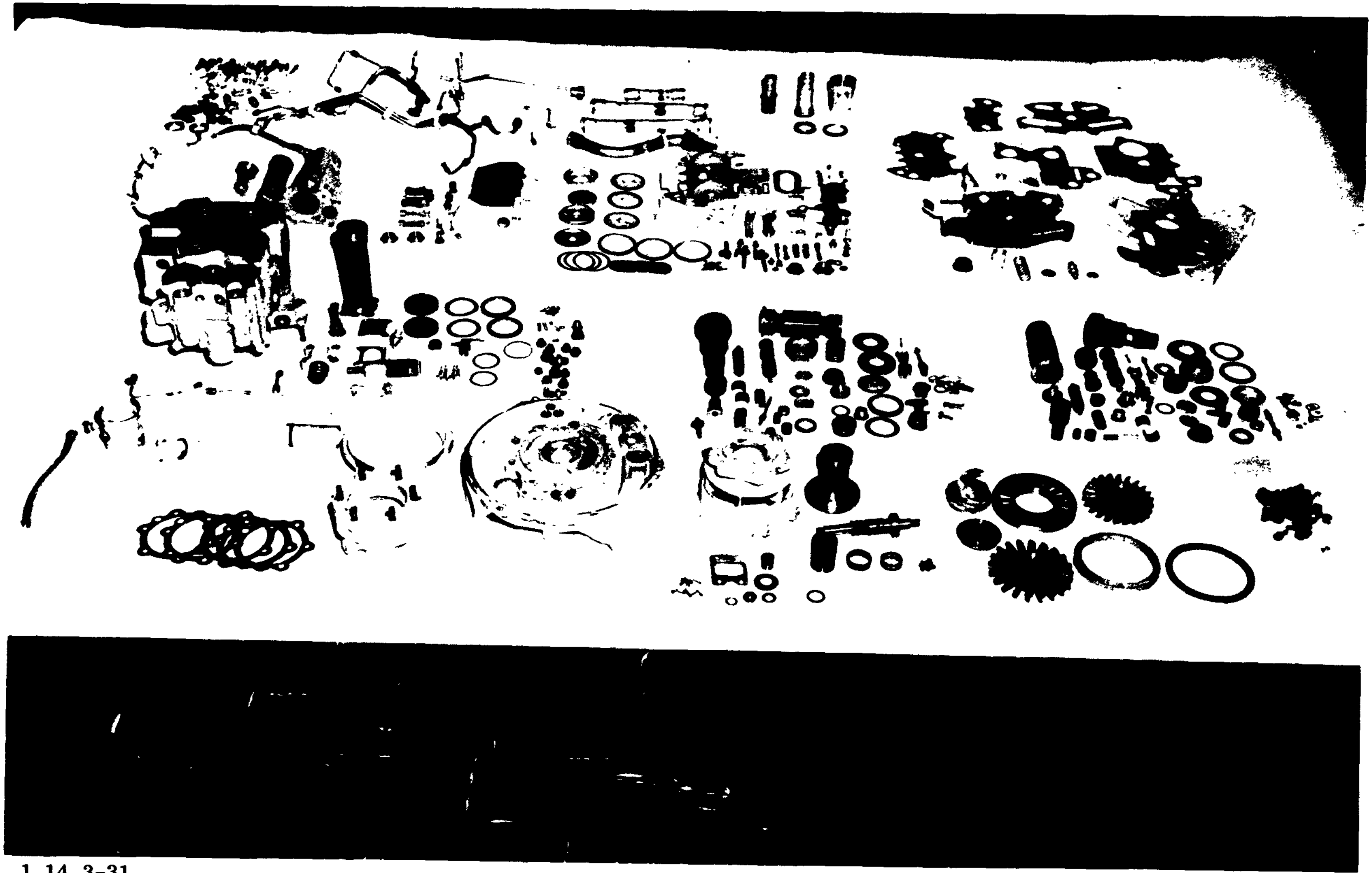
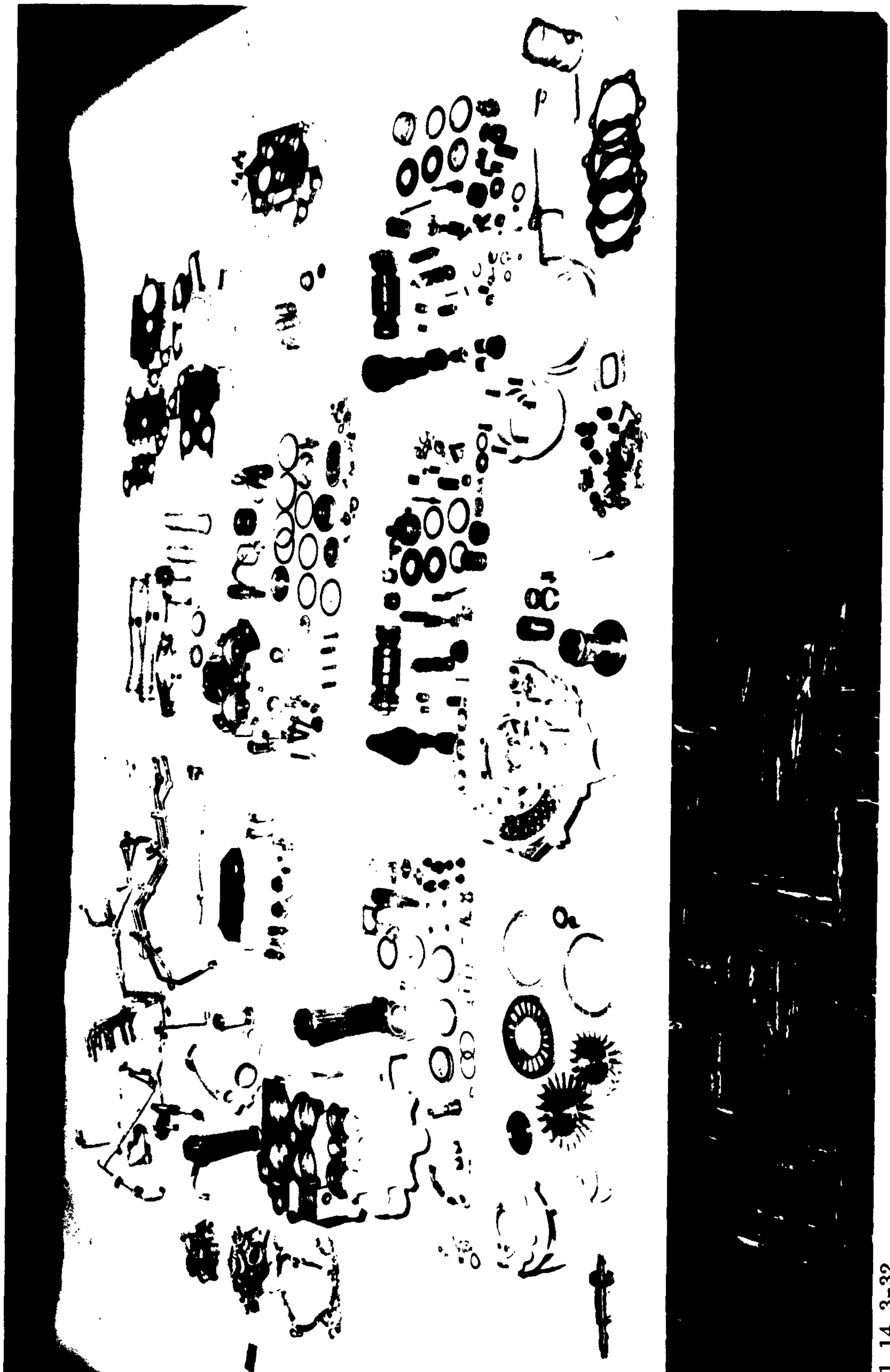


1.14.3-31

FIGURE 17 - Disassembled Components of RJ43-MA-11 Fuel Control Unit Serial 002, From Engine Serial MA-E10002-2, Following the RJ43-MA-11 Phase I Long Term Storage Test.



1.14.3-32 FIGURE 18 - Disassembled Components of Spare RJ43-MA-11 Fuel Control Unit Serial 007 Following the RJ43-MA-11 Phase I Long Term Storage Test.

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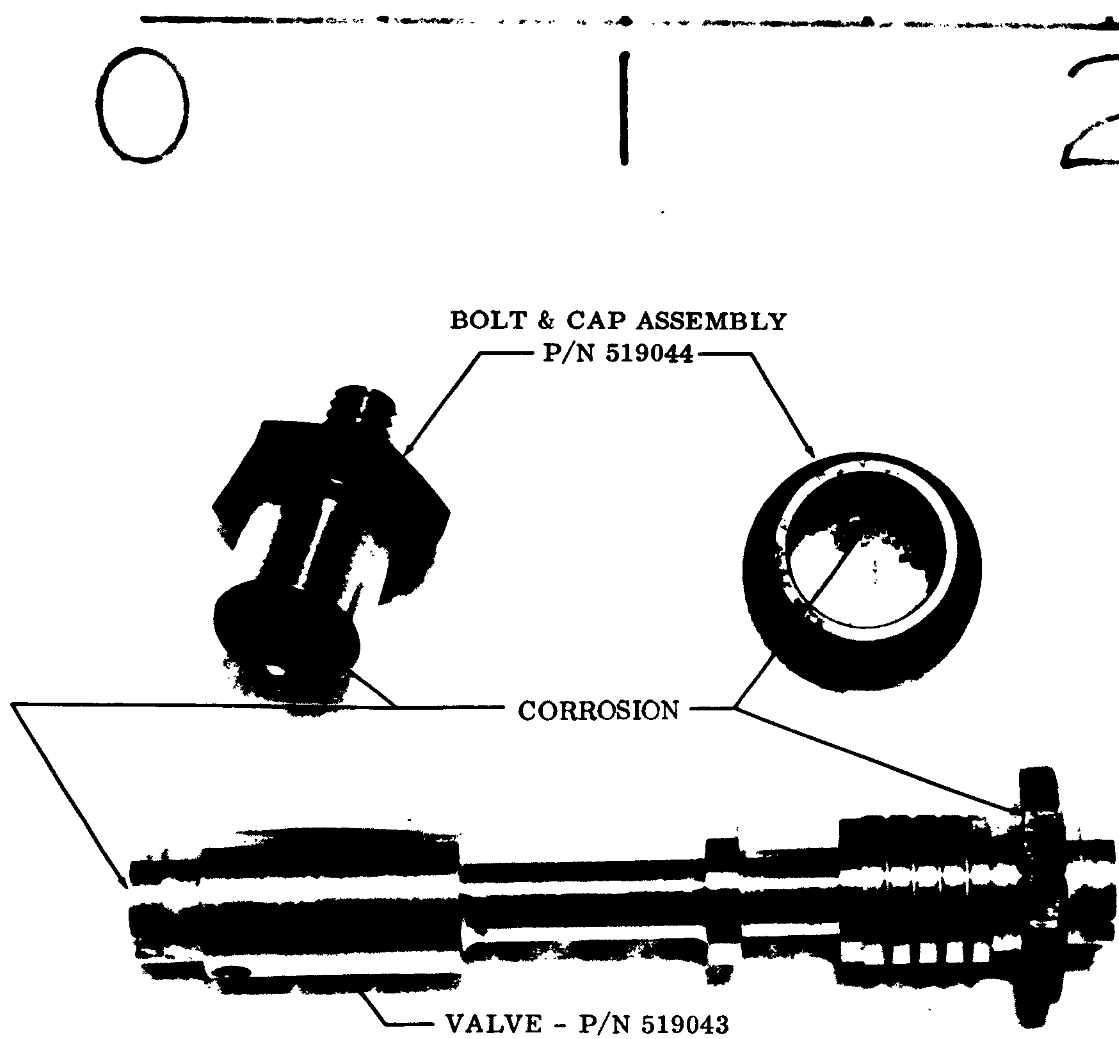
C2728



1.14.3.-25

FIGURE 19 - Shock Position Control Valve and Bolt and Cap Assembly From RJ43-MA-11 Fuel Control Unit Serial 002 Showing Corrosion Caused by Improper Test Procedures Which Followed the RJ43-MA-11 Phase I Long Term Storage Test.

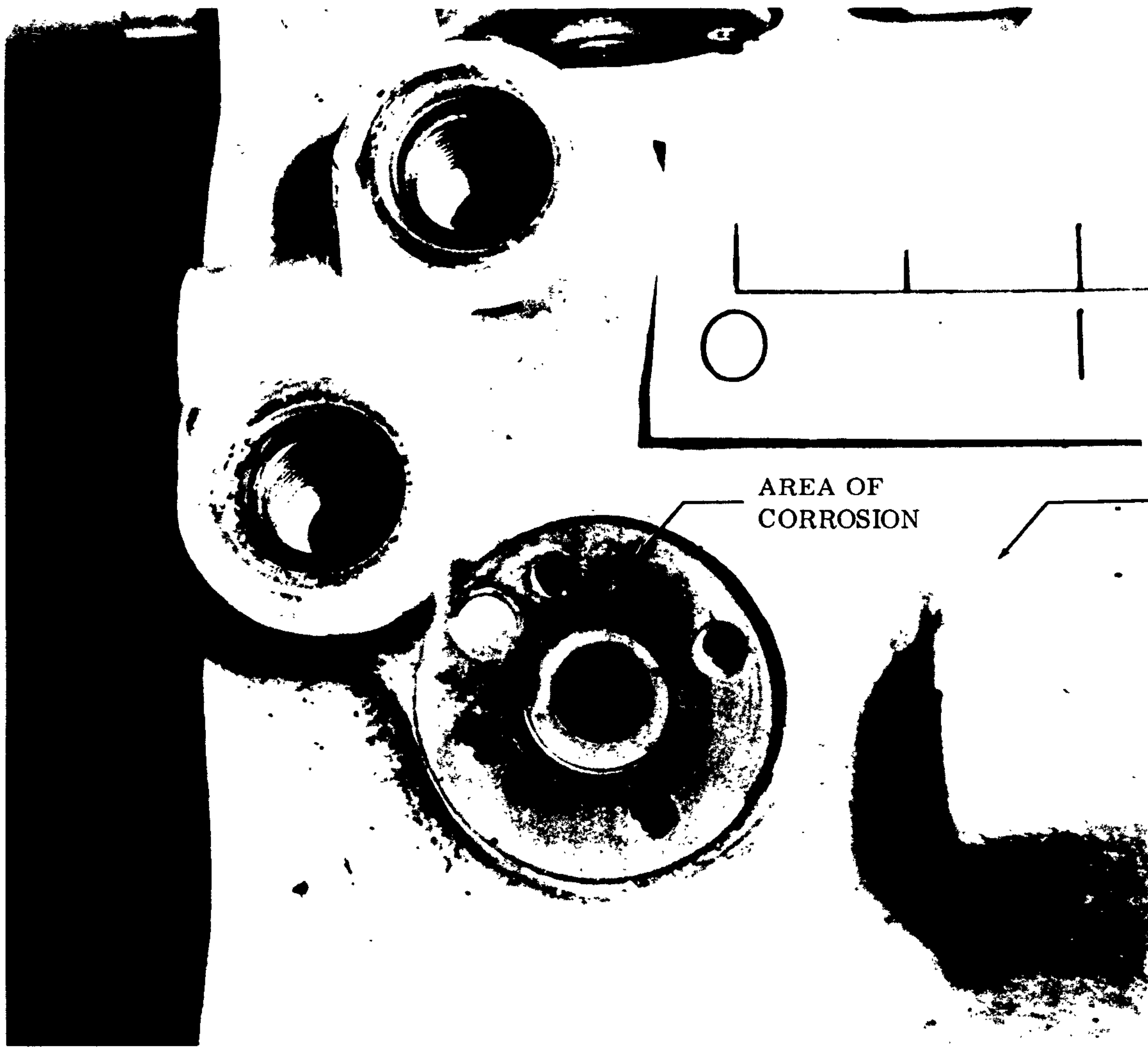


FIGURE 20 - Mach Senser-Shock Position Control Housing From RJ43-MA-11 Fuel Control Unit Serial 007 Showing Minor Area of Corrosion Discovered Following Completion of the RJ43-MA-11 Phase I Long Term Storage Test.

V CONCLUSIONS

The following conclusions are based on the results of the Phase I long-term storage test program and refer to engines, combustion chambers and fuel control units stored in their respective shipping/storage containers.

1. The life of the engine appears to be compatible with the design life objective of ten years.

2. A two-year interval for conduct of functional confidence checks is compatible with the design of the power control system.

3. Storage containers require a minimum amount of maintenance or servicing effort to insure a satisfactory internal storage environment.

4. Condition of the test hardware at the completion of the test program indicated no necessary changes in engine design, manufacturing processes, handling procedures or maintenance and servicing concepts to improve the storage capability of the engine. One possible exception to this would be to caution against the excessive use of leak detection soap.

VI REFERENCES

1. Marquardt Report S-1001B (Title Unclassified), Engineering Program Plan for Qualification of the RJ43-MA-11 Ramjet Engine, dated 17 February 1960, revised 20 May 1960. CONFIDENTIAL.

2. Marquardt Engineering Drawing 221900, Packaging and Shipping Instructions RJ43-MA-11 Engine, dated 23 June 1960.

3. Marquardt Process Specification 1306D, Preparation of RJ43 Engines for Storage and Shipment, dated 16 February 1953, revised 5 April 1960.

4. Marquardt Test Specification 0191G, Acceptance Test Specification for the RJ43-MA-11 Ramjet Engine, dated 15 October 1959, revised 30 September 1960.

5. Marquardt Test Specification 0206G, Performance and Calibration Requirements 519000 Fuel Control Unit, dated 23 June 1959, revised 14 October 1960.

6. Marquardt Report 15039, Environmental Testing of Three Selected RJ43-MA-11 Ramjet Engines and One Fuel Control Unit, dated 11 July 1960.

7. Military Specification MIL-E-5272C (ASG), Environmental Testing, Aeronautical and Associated Equipment, General Specification for, dated 13 April 1959.

8. Marquardt Test Specification 9205L, Performance and Calibration Requirements for the Turbopump Assembly, dated 14 September 1959, revised 9 July 1962.

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